



MICROMANIPULATOR
Probing the Limits of Technology™

**H-1000
THERMAL CHUCK
SYSTEM
OPERATIONS
MANUAL**



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CAUTION: *CAUTION statements identify conditions or practices that could result in damage to this product or other property.*

NOTES

SECTION 1.0 INTRODUCTION

1.1 HOW TO USE THIS MANUAL

Read Section 1.0 for general information regarding the **H1000 THERMAL CHUCK SYSTEM™**. For unpacking and setup information and equipment familiarization, read Section 2.0. For information regarding how to operate this equipment and instructions that will serve to introduce several equipment familiarization procedures, read Section 3.0. Section 4.0 provides the PRINCIPLES OF OPERATION for the system. Sections 5.0 covers the 0 ° cooling option. Section 6.0 provides maintenance and repair methods and recommended spare parts.

1.2 SYSTEM OVERVIEW

The **H1000 THERMAL CHUCK SYSTEM™** (Ref. Fig. 1-1) is a modular approach to providing customized temperature controlled platforms for testing wafers. The various modules are the Heat Control Module, Cooling Module, Thermal Chuck Assembly, and optional Linear DC Power Supply.

The most BASIC SYSTEM consists of a HEAT CONTROLLER and THERMAL CHUCK for the appropriate wafer prober. This would provide a low cost Heat only Thermal Chuck testing system. This system would allow operation from ambient to 400 ° C. This system can be expanded by adding one or more options to it. For example, by inserting a COOLING MODULE into the space provided in the original Heat Controller and plumbing in the Cooling module accessories, the Thermal Chuck can be cooled more rapidly when required. When the correct Cooling Option is selected, the Thermal Chuck can even be cooled below ambient. A Linear DC Power Source can also be added for those who require the Thermal Chuck to be electrically "quiet". These options can be added together or separately to provide the desired end configuration.

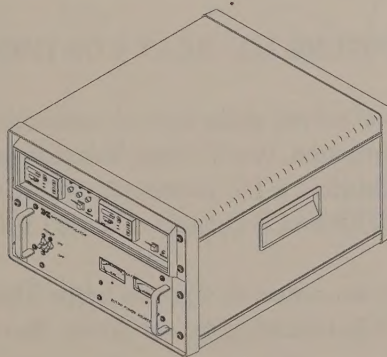


**FIGURE 1-1. H1000 THERMAL CHUCK SYSTEM
(SHOWN WITH DC POWER SOURCE)**

1.3 GENERAL DESCRIPTION

The most Basic system consists of a Heat Controller and Thermal Chuck system which would allow operation from ambient to 400 ° C. Some form of coolant must be circulated through the radiators of the Thermal Chuck during normal operation. Two hoses are provided with each system for connection to and from the radiators. These hoses are connected to the assembly with quick connect couplings that have internal shut off inside of them.

The most basic Heat Controller (H1000) (Ref. Fig. 2) would use AC power to drive the thermal chuck. A special "burst firing" control of the AC provides a low noise AC drive to the Thermal Chuck. The H1000 Heat Controller is designed to work in conjunction with the DC100 power source that drives the thermal chuck with an extremely "clean" DC Power. PID temperature control is provided with both the AC and DC power.

The Heat Controller is packaged in a 19" rack mountable 5 1/4" high by 13 1/2" deep enclosure. Power and actuation control for a cooling option is integrated into the heat module. All manual controls governing actuation and temperature set point control are located on the Heat Controller's front panel.

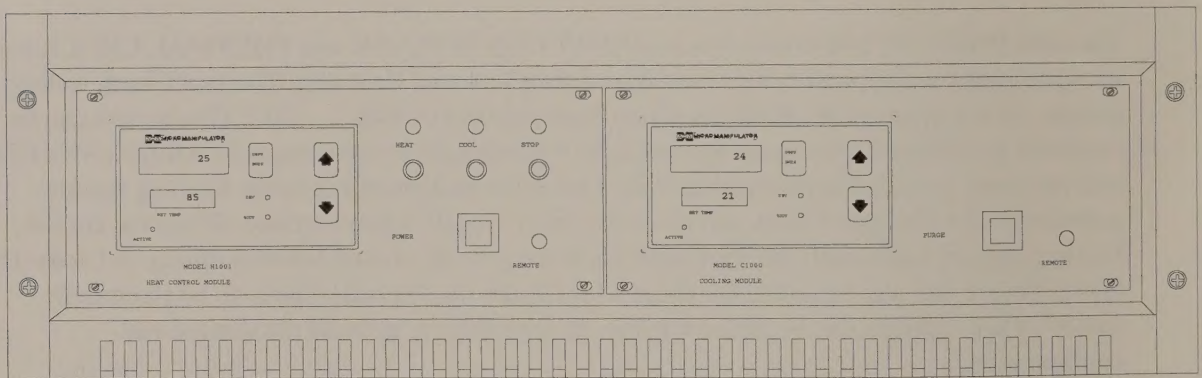


FIGURE 1-2. HEAT CONTROLLER

The Heat Controller's rear panel serves as the central connection point for all options. Located on the rear panel are the, AC power inlet, two Voltage Selector switches, appropriate circuit breakers (two for AC power chucks), a T/C connector, a CHUCK connector an INTERFACE connector, a COMPUTER INTERFACE connector, a red LIMIT indicator, and a RESET switch.

The Heat Controller provides two connection points to the Thermal Chuck; the T/C (temperature control sensors) and the CHUCK (electrical heater drive). See block diagram.

The INTERFACE connector provides the interconnection of other options such as the Cool Module and/or the DC power source. The COMPUTER INTERFACE connector is a seven position Viking connector wired to provide access for 422 serial control of the module.

1.4 OPTIONS

The H1000 Thermal Chuck System has several option which can be added to the basic heat-only system. Each of these options are discussed in brief in this section. Detailed information can be found in the appropriate section for the particular option.

1.4.1 Cooling options

The H1000 Thermal Chuck System has three different cooling options to choose from. The H1000 Thermal Chuck System can be purchased with one of these options or upgraded at a later time.

AMBIENT COOLING OPTION (C1000-V0-H)

This cooling option provides the capability to cool the thermal chuck to the temperature of water supplied by the user. The user must also supply a drain for the cooling water. The system automatically purges the cooling water from the chuck after the 'cold' temperature set point is reached. The 'cold' temperature is not controlled by this cooling option. Temperature stability is maintained using the heat controller. The C1000-V0-H cooling option provides the necessary plumbing to provide continuous water cooling for the radiator portion of the thermal chuck.

This system includes the cooling module, service module (SRV1) (Ref. Fig. 1-3), tubing and interconnecting cables.

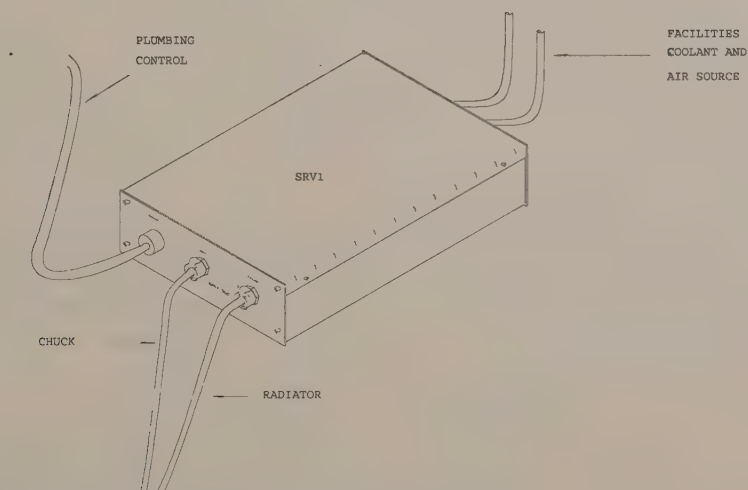


FIGURE 1-3. SERVICE MODULE (SRV1)

AMBIENT COOLING OPTION (C1000-V1-HE and C1000-V2-HE)

This cooling option provides the capability to cool the thermal chuck to the temperature of the ambient air. This cooling option includes an external self-contained heat exchanger which circulates a cooling fluid (usually DI water or water/glycol mixture) to cool both the chuck radiator and chuck surface as required. The system is equipped with an initial supply of cooling fluid. The fluid level is maintained by the user as evaporation occurs. The 'cold' temperature is not controlled by this cooling option. Temperature stability is maintained using the heat controller. This cooling option includes the cooling controller, heat exchanger, tubing and interconnecting cables. The heat exchanger may be ordered with a 19" rack mount kit which occupies 6U (10.5") of rack space.

ZERO °C COOLING OPTION (C1000-V1-C-0 and C1000-V2-C-0)

This cooling option provides the capability to cool the thermal chuck to 0°C. This cooling option includes an external refrigeration unit which chills a cooling fluid that flows through the chuck radiator and body as required. The cooling fluid is a mixture of water and glycol. The 'cold' temperature is controlled by the cooling controller which controls the flow of the cooling fluid through the chuck. This cooling option includes the cooling controller, service module (SRV1), refrigeration unit, tubing and interconnecting cables.

1.4.2 Linear DC Power Source (DC-100)

The most basic H1000 heat controller is equipped to supply AC power to heat the thermal chuck. Some thermal chuck applications require the use of "clean" DC power (Ref. Fig. 1-4) to eliminate electric fields created when AC power is used. The H1000 Thermal Chuck System can be configured to supply DC heating power to chuck. AC powered systems can be upgraded to use DC power.

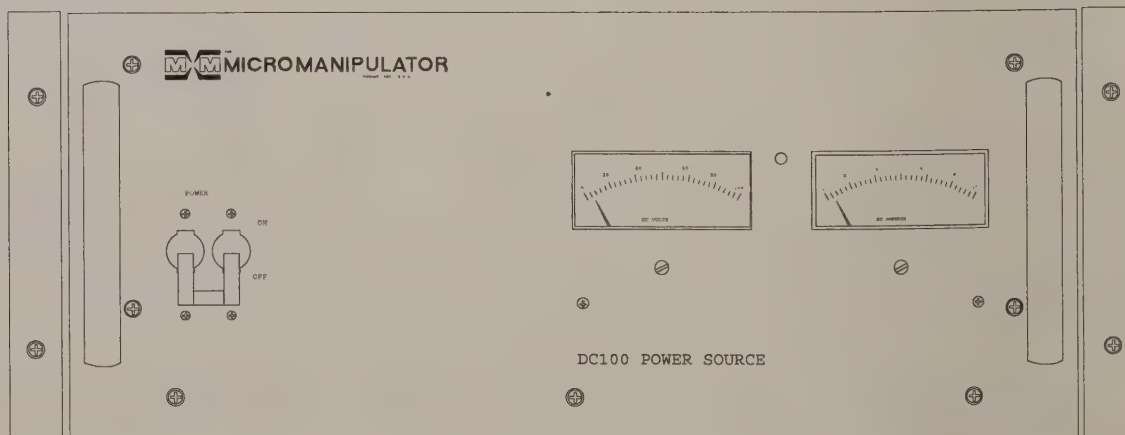


FIGURE 1-4. DC POWER SOURCE (DC-100)

1.4.3 Computer Interface Options (Ref. Fig. 1-5)

In addition to front panel control, the H1000 Thermal Chuck System can be controlled by a computer. There are three interface options available.

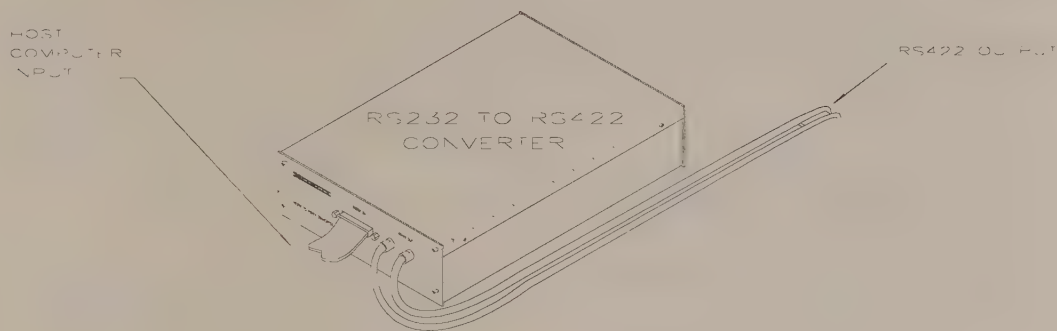


FIGURE 1-5. COMPUTER INTERFACE

RS-232 INTERFACE (H1000-RS-232)

The "native" communications method designed into the H1000 controllers is RS-422. The H1000-RS-232 option allows a remote controller to communicate with the H1000 controllers via RS-232. The command reference for the H1000 temperature controllers can be found in Appendix A of this manual.

GPIB INTERFACE (H1000-IEEE)

This communications option allows a remote controller to communicate with the H100 controllers via a standard IEEE (488) interface. The command reference for the H1000 temperature controllers can be found in Appendix B of this manual.

RS-422 INTERFACE (H1000-RS-422)

This interface option provide the necessary hardware to connect the H1000 controllers to a RS-422 interface, 25 pin connector. The command reference for the H1000 temperature controllers can be found in Appendix C of this manual.

1.5 SPECIFICATIONS

THERMAL CHUCK:

SURFACE PREPARATION:	Platinum sputtered surface.
SURFACE FLATNESS:	50 uM (ambient to 300° C)
HEIGHT:	1.85" when equipped with mounting for MICROMANIPULATOR probe stations.
SURFACE PLANARITY:	Planarizable at factory or field.
ELECTRICAL ISOLATION:	
COAXIAL:	Surface to ground @25° C, 500 VDC > 100 Gohm Surface to ground @400° C, 500 VDC > 1 Gohm
ADVANCED COAXIAL:	Surface to ground @25° C, 500 VDC > 5 Tohm Surface to ground @400° C, 500 VDC > 5 Gohm
TRIAXIAL:	Surface to ground @25° C, 500 VDC > 10 Tohm Surface to guard @25° C, 500 VDC > 5 Tohm Surface to ground @400° C, 500 VDC > 10 Gohm Surface to guard @400° C, 500 VDC > 5 Gohm
CAPACITANCE	
COAXIAL:	4" Surface to ground < 200 pF 6" Surface to ground < 300 pF 8" Surface to ground < 400 pF
TRIAXIAL:	4" Surface to ground < 150 pF 6" Surface to ground < 250 pF 8" Surface to ground < 400 pF
CAPACITANCE VARIATION:	< 3 fF
VERTICAL EXPANSION:	< 10um per 100° C
DIAMETER:	Available in 4", 6", and 8" Consult factory for other configurations.
TEMPERATURE CAPABILITY:	-65° C to +400° C
FACILITY REQUIREMENTS:	Vacuum 25" Hg nominal

HEAT CONTROLLER:

(H1000-AC1-V1, H100-AC1-V2, H1000-DC1-V1, H1000-DC1-V2)

CONTROL METHOD:	PID control
POWER OUTPUT:	
H1000-AC1-V1, H1000-AC1-V2	AC, 1200 watts
H1000-DC1-V1, H1000-DC1-V2	DC, 1000 watts
TEMPERATURE RANGE:	to 400° C
TEMPERATURE ACCURACY:	+/- 0.1% of span, +/-1 LSD, (25°C +/- 3°) ambient at rated line voltage (100 - 240 VAC) +/- 10%
TEMPERATURE STABILITY:	0.1°C per 1°C change in ambient
TEMPERATURE RESOLUTION:	0.1° C
CYCLE TIME PERFORMANCE:	Ambient to 300° C $\leq$ 12 min. and ambient to 400° C $\leq$ 30 min..
AMBIENT OPERATING TEMPERATURE:	10 to 40° C.
OVER TEMPERATURE PROTECTION AT:	425° C.
TEMPERATURE DISPLAY:	Green LED chuck temperature; red LED set point temperature.
STATUS INDICATORS:	Heating, fault, % deviation of set point, % power being delivered.
COMPUTER CONTROL:	Optional interfaces available for: RS-422, RS-232 or GPIB(IEEE)
FACILITY REQUIREMENTS:	
H1000-AC1-V1, H1000-DC1-V1	120 VAC, 60Hz, 20A, 1 phase
H1000-AC1-V2, H1000-DC1-V2	220 VAC, 50Hz, 10A, 1 phase

AMBIENT COOLING OPTION (C1000-V0-H):

CONTROL METHOD:	PID
TEMPERATURE RANGE:	Cools to temperature of user supplied water
TEMPERATURE RESOLUTION:	Not applicable
TEMPERATURE STABILITY:	Not applicable
CYCLE TIME PERFORMANCE:	400° C to 100° C <6 min. 400° C to 40° C < 9 min with 10° C cooling water
TEMPERATURE DISPLAY:	Green LED chuck temperature; red LED set point temperature.
STATUS INDICATORS:	Cooling, fault, % deviation of set point, % power being delivered.
COMPUTER CONTROL:	Optional interfaces available for: RS-422, RS-232 or GPIB(IEEE)
FACILITY REQUIREMENTS:	Shop air @ 10 - 65 Psig Cooling water @ 20 - 65 Psig @ 20 gal/hr Water drain

AMBIENT COOLING OPTION (C1000-V1-HE, C1000-V2-HE):

CONTROL METHOD:	PID
TEMPERATURE RANGE:	Cools to ambient air temperature
TEMPERATURE RESOLUTION:	Not applicable
TEMPERATURE STABILITY:	Not applicable
CYCLE TIME PERFORMANCE:	400° C to 100° C <7 min. 400° C to 40° C < 10 min with 20° C cooling water
TEMPERATURE DISPLAY:	Green LED chuck temperature; red LED set point temperature.

STATUS INDICATORS:	Cooling, fault, % deviation of set point, % power being delivered.
COMPUTER CONTROL:	Optional interfaces available for: RS-422, RS-232 or GPIB(IEEE)
COOLING FLUID:	De-ionized water or water/glycol mixture
RESERVOIR CAPACITY:	2.5 gallons
FACILITY REQUIREMENTS:	C1000-V1-HE: 115 VAC, 60 Hz @ 2A C1000-V2-HE: 220 VAC, 50 Hz, @ 2A Shop air @ 20 - 65 Psig

ZERO °C COOLING OPTION (C1000-V1-C-0, C1000-V2-C-0):

CONTROL METHOD:	PID
TEMPERATURE RANGE:	Cools to 0° C, within 6°C of chiller temperature
TEMPERATURE RESOLUTION:	+/- 0.1° C
TEMPERATURE STABILITY:	+/- 1° C
CYCLE TIME PERFORMANCE:	TBD
TEMPERATURE DISPLAY:	Green LED chuck temperature; red LED set point temperature.
STATUS INDICATORS:	Cooling, fault, % deviation of set point, % power being delivered.
COMPUTER CONTROL:	Optional interfaces available for: RS-422, RS-232 or GPIB(IEEE)
COOLING FLUID:	Water/glycol mixture
RESERVOIR CAPACITY:	0.53 gallons (2 liters)
FACILITY REQUIREMENTS:	C1000-V1-C-0: 120 VAC, 60 Hz @ 8A C1000-V2-C-0: 220 VAC, 50 Hz, @ 5A Shop air @ 20 - 65 Psig

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

NOTES

SECTION 2.0 INSTALLATION AND SETUP PROCEDURES

2.1 PRE-INSTALLATION PROCEDURES

2.1.1 Shipping Carton Inspection

Carefully check the packing materials for signs of visible damage when they are received. If any damage is noted, photograph the damage carton(s) immediately and contact the shipping company to report the damage and to obtain a damage claim form. Notify **The MICROMANIPULATOR Co., Inc.** Service Department.

2.1.2 Instrument Removal

While removing the test station from the carton(s), check all components for shipping damage. If possible, photograph any damage for use when claims are submitted to the shipping company. Notify the shipping company and **The MICROMANIPULATOR Co., Inc.** immediately. We will not be responsible for shortages unless they are reported at the time of receipt. Include the following on all claim reports:

**INSTRUMENT MODEL NUMBER
INSTRUMENT SERIAL NUMBER
YOUR PURCHASE ORDER NUMBER
YOUR LIST OF THE SHORTED MATERIALS**

2.1.3 Instrument Inspection

All instruments should be thoroughly inspected upon receipt. If the contents are damaged, or the instrument fails to operate properly, the carrier and **The MICROMANIPULATOR Co. Inc.** must be notified at once. The following documents are required to support claim:

**ORIGINAL FREIGHT BILL AND BILL OF LADING
ORIGINAL INVOICE OR PHOTOCOPY OF ORIGINAL INVOICE
COPY OF PACKING LIST
PHOTOGRAPHS OF THE DAMAGED EQUIPMENT AND CONTAINER(S)**

Should any damage be noted, contact **The MICROMANIPULATOR Co., Inc.,** Customer Service Department. The telephone numbers are listed in the "i" pages at the front of this manual. The company will aid in getting your instrument up and running as soon as possible.

2.2 INSTALLATION AND SETUP (Ref. Fig. 2-1)

2.2.1 Thermal Chuck

The THERMAL CHUCK (Ref. Fig. 2-1 & 2) is connected to a prober via **one** electrical connector, **one red** silicone hose for vacuum, **two white** silicone hoses with male quick connects for radiator cooling, and **two red** hoses with female quick connects for chuck cooling. The prober will be internally plumbed to accept the thermal chuck. To connect the thermal chuck to the prober, first connect the thermal chuck's vacuum hose to the wafer chuck vacuum nipple on the prober. Then connect all electrical connectors and plumbing quick connects to their mating counterparts on the prober. The CHUCK POTENTIAL electronic connector is a single UMC coaxial connector mounted on a four inch piece of coaxial cable attached to the bottom side of the chuck. This UMC connector mates directing with the signal cable which is a part of the probe station plumbing. If the prober is equipped with Kelvin connections to the chuck, a Model 45-2F can be employed to connect both of the Chuck signal cables to the THERMAL CHUCK assembly. The Model 45-2F allows the dual cabling to be attached at the chuck thus allowing the HP 4284 style LCR instrument to correct for the added inductance of the probe station's internal cabling to minimize errors. This significantly reduces the error compared to "teeing" the instrument cabling outside of the prober.

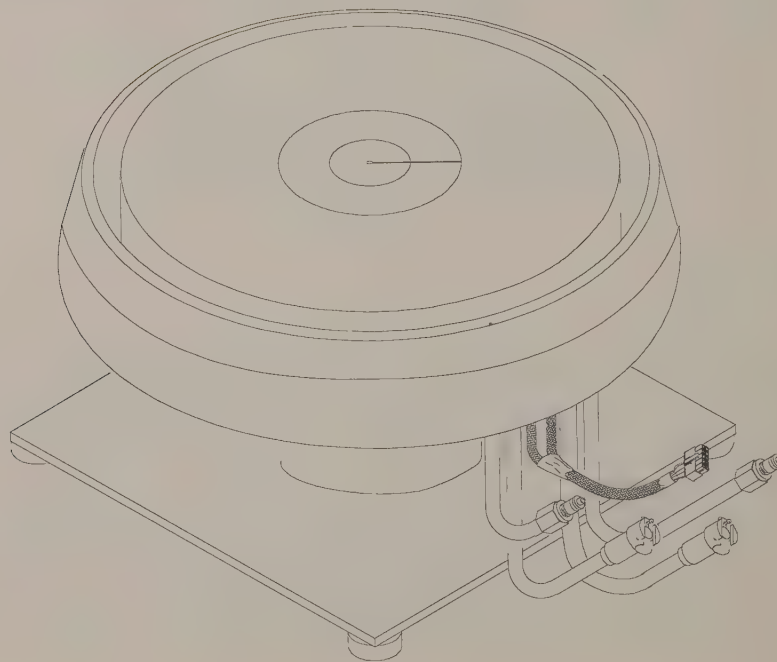


FIGURE 2-1. THERMAL CHUCK (TOP VIEW)

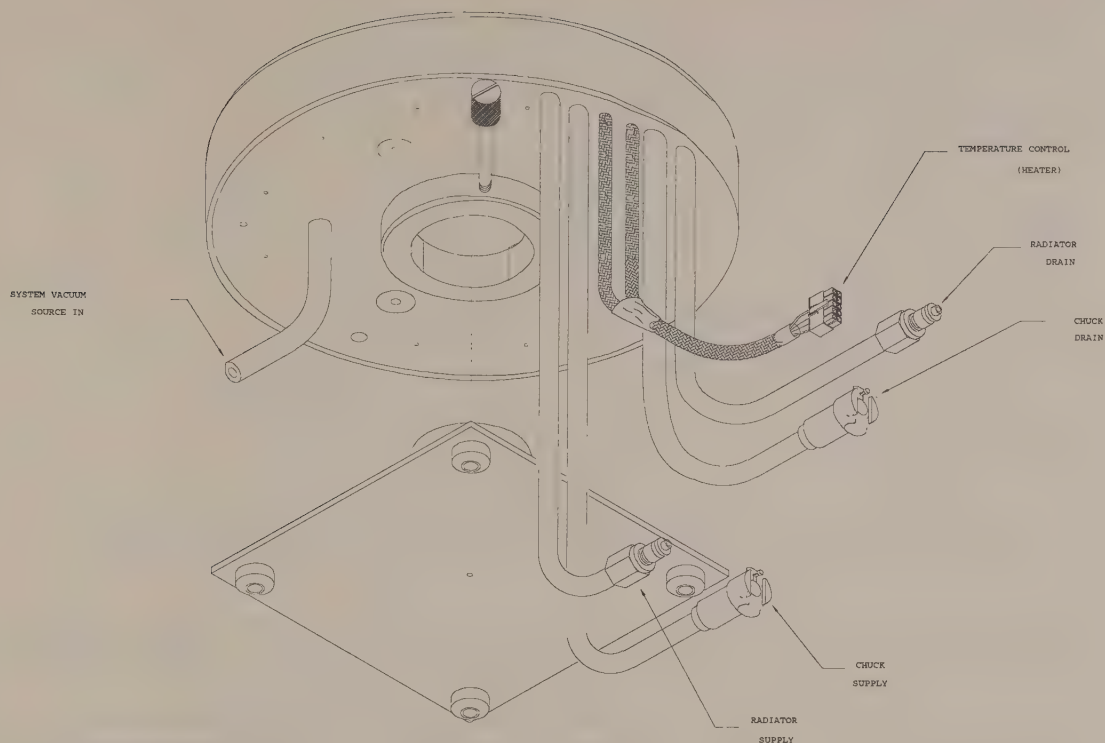


FIGURE 2-2. THERMAL CHUCK (BOTTOM VIEW)

The chuck has four hoses which connect to the four fittings on the probe station. Figure 2-2 identifies the hoses as:

- Radiator supply
- Radiator return
- Chuck supply
- Chuck return

Figure 2-3 identifies the four fittings on the probe station with the same nomenclature. Be sure to connect the four hoses to the correct fittings in the probe station. Incorrect hose connections can adversely affect thermal chuck performance.

Cooling fluid that flows through the radiator portion of the chuck is at the temperature of the chiller reservoir. Condensation will form on the outside of the radiator when operating the chiller at temperatures below the dew point of the air surrounding the chuck. It is highly recommended to maintain the environment around the chuck at a dew point at least 10° C below the temperature of the chiller setting. To ensure that water formed by condensation does not drip into the probe and cause malfunctions, a tube of Dielectric Silicone Compound is supplied with the thermal chuck. Be sure to spread a film of the compound around the rectangular connector under the chuck to prevent damage due to dripping water.

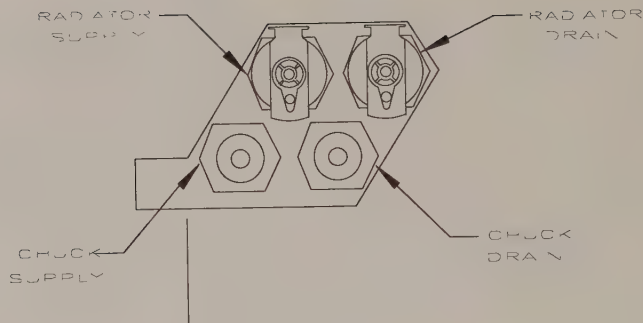


FIGURE 2-3.
COOLING FLUID FITTINGS FOR 8000 SERIES PROBE STATION

2.2.2 Heat Controller (H1000-AC1-V1, H1000-AC1-V2, H1000-DC1-V1, H1000-DC1-V2)

Once the thermal chuck is installed on the prober, the HEAT CONTROLLER should be connected to the prober (Ref. Fig. 2-3 for unit panel locations). The prober has a panel mounted on the rear of the station that provides a convenient interface of the prober (Ref. Fig. 2-4 for electrical hookup) to the various components of the H1000 Thermal Chuck System. On this panel are two electrical connectors and 5 plumbing (quick connects) connectors. The two electrical connectors are connected to the identically labeled connectors on the rear of the HEAT CONTROLLER with the supplied extension cables.

2.2.3 Ambient Cooling Option (C1000-V0-H)

HOOKUP:

The C1000-V0-H cooling option requires user supplied air, water and water drain. The Cool Module is factory installed in the cabinet with the heat controller. The interface connection between the heat and cool controllers should also have been made at the factory. The user setup requires the hookup of the Service Module (SRV1) to the water and air supply, the probe station and to the Cool Module.

There are six hoses supplied with the C1000-V0-H cooling option. Refer to Figure 2-5 for system hose hookups. The yellow polyethylene hose is used to connect the SRV1 Chuck Assembly Supply to the Chuck Supply on the rear of the probe station. The blue polyethylene hose is used to connect the SRV1 Radiator Supply to the Radiator Supply on the rear of the probe station.

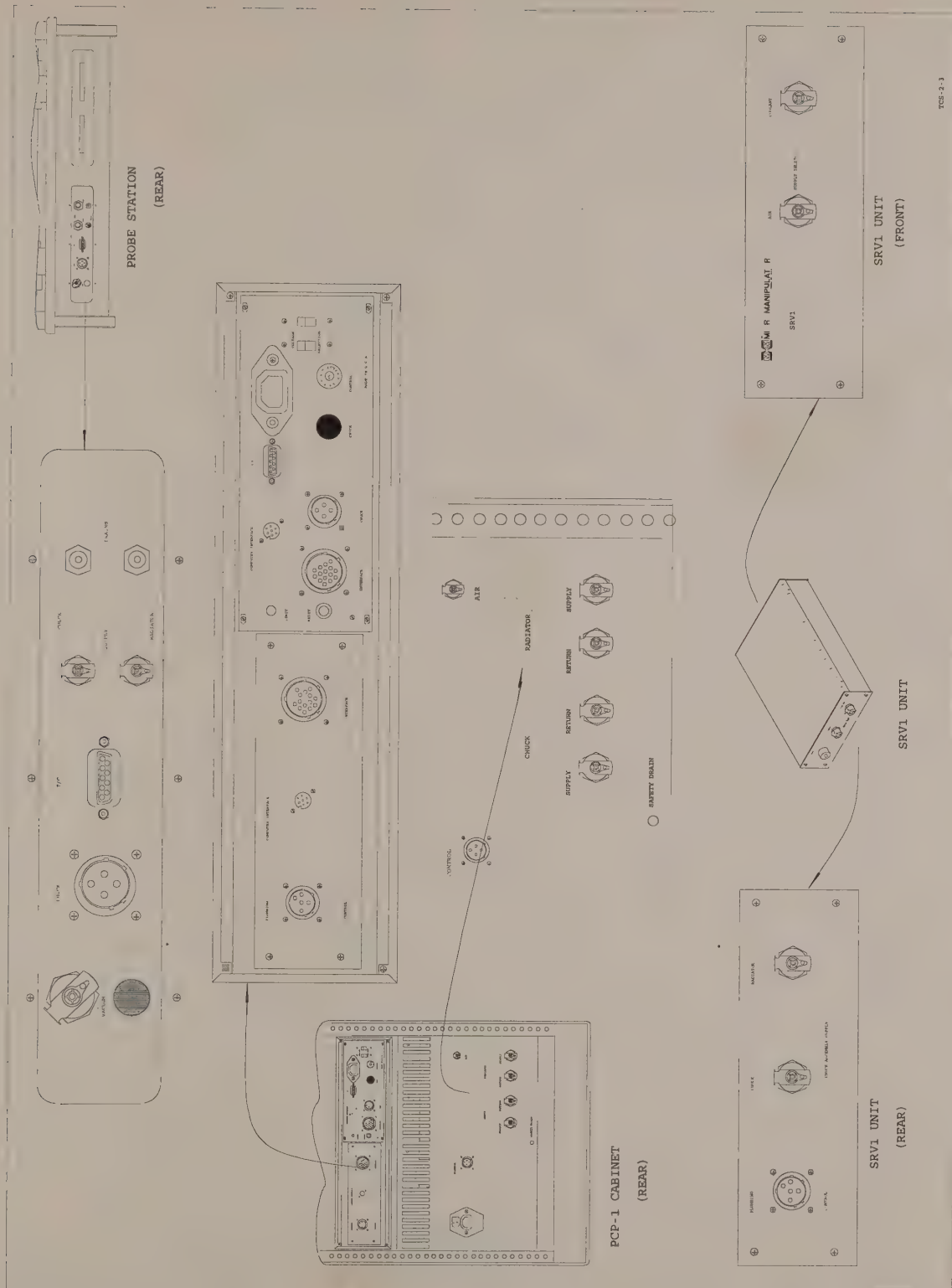


FIGURE 2-4. AMBIENT COOLING UNIT PANEL LOCATIONS

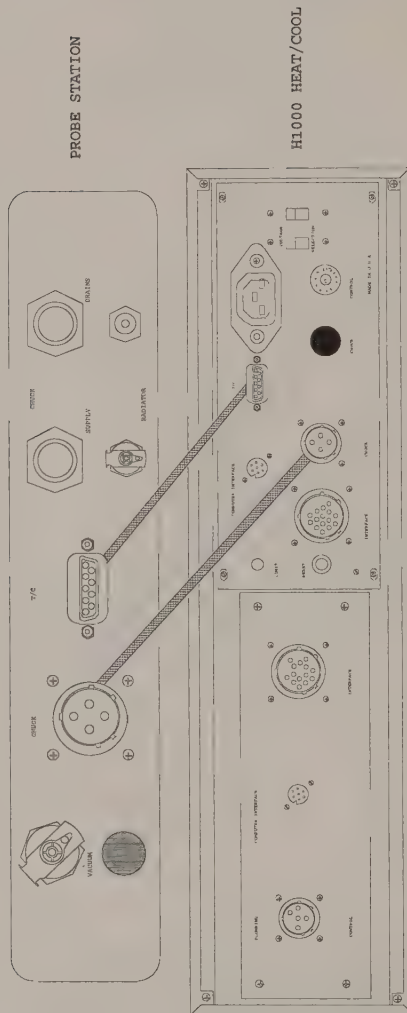


FIGURE 2-5. HEAT CONTROL MODULE HOOKUP

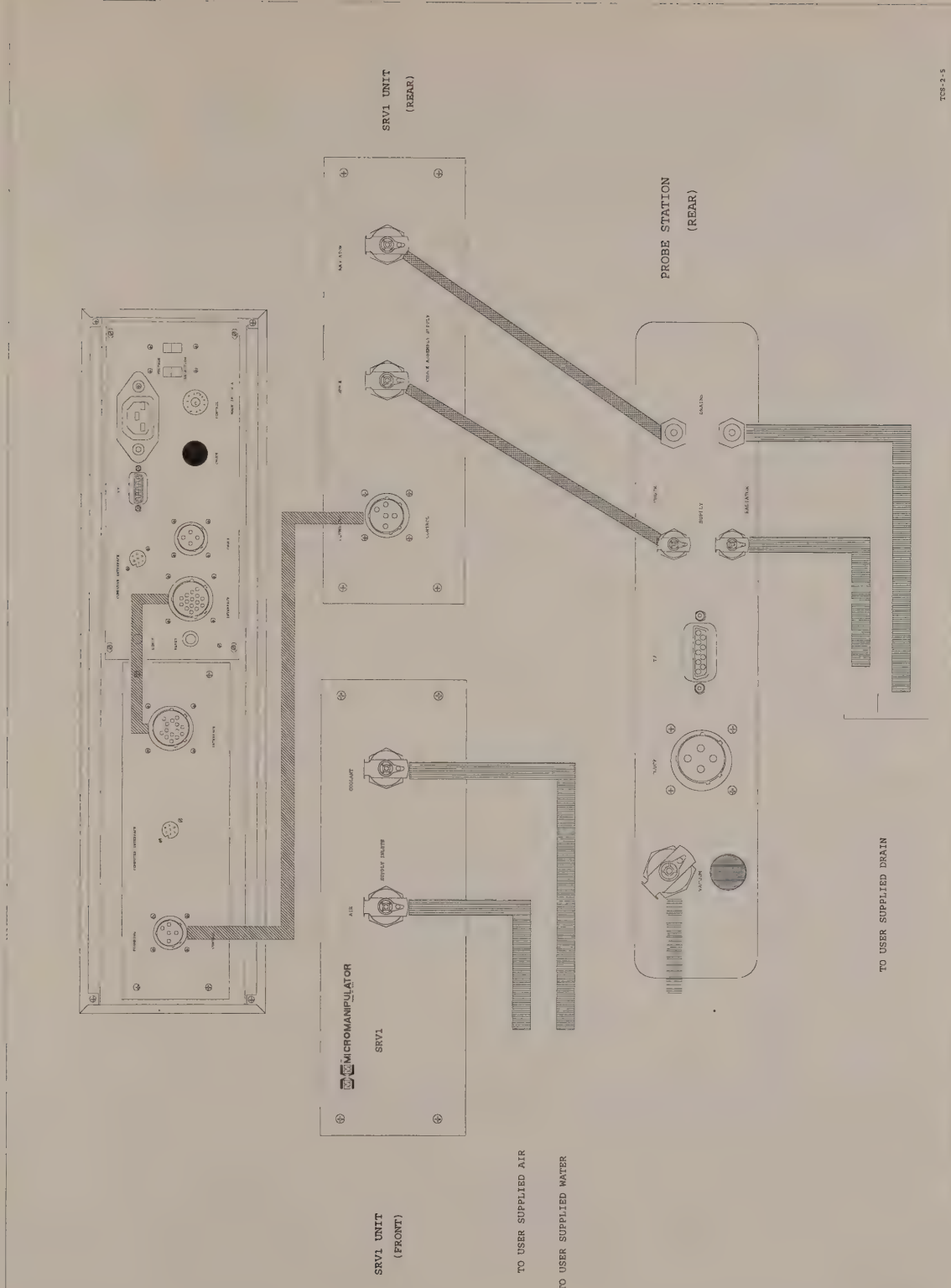


FIGURE 2-6. AMBIENT COOLING HOOKUP WITHOUT HEAT EXCHANGER (C1000-V0-H)

The two red silicone hoses are used to connect the Chuck and Radiator drains from the probe station to the user supplied drain. The red polyethylene hose is use to connect the user supplied water to the water inlet on the SRV1. The clear polyethylene hose is use to connect the user supplied air to the air inlet on the SRV1. The connector on the SRV1 labeled Plumbing Control is connected to the Plumbing Control connector on the rear of the Cool Module using the extension cable provided.

2.2.4 Ambient Cooling Option (C1000-V1-HE, C1000-V2-HE)

PREPARATION:

The Heat Exchanger is shipped empty and must be filled with either de-ionized or a mixture of glycol and water to become serviceable. A gallon of commercial grade anti-freeze is included with the heat exchanger. Using the entire 1 gallon of anti-freeze and adding water to fill the reservoir will result in an appropriate water/glycol mixture. The fill port is located on the top of the unit under the sliding cover. In most cases, the Heat Exchanger will have to be 'burped' to remove any air trapped in the internal hoses and/or pump. To do this, use the yellow polyethylene hose to connect the Radiator Supply to the Radiator Return on the rear of the Heat Exchanger. Turn the system on and off using the power switch on the rear of the Heat Exchanger until the system is free of air and pumping properly. Wait 15-20 seconds before turning power back on or off. It may be necessary to tilt up the left side and/or front of the heat exchanger to allow any trapped air in the system to escape.

HOOKUP:

The C1000-V1-HE and C1000-V2-HE cooling options include a self contained heat exchanger which eliminates the need for the user to supply a water and drain for cooling purposes. The Cool Module is factory installed in the cabinet with the heat controller. The interface connection between the heat and cool controllers should also have been made at the factory. The user setup requires the hookup of the Heat Exchanger to the probe station and to the Cool Module.

There are five hoses supplied with the C1000-V1-HE and C1000-V2-HE cooling options. Refer to Figure 2-6 for hose hookups. The yellow polyethylene hose is used to connect the Heat Exchanger Chuck Supply to the Chuck Supply on the rear of the probe station. The blue polyethylene hose is used to connect the Heat Exchanger Radiator Supply to the Radiator Supply on the rear of the probe station. The two red silicone hoses are used to connect the Chuck and Radiator drains from the probe station to the Heat Exchanger Chuck and Radiator Returns. The clear polyethylene hose is use to connect the user supplied air to the air inlet on the Heat Exchanger. The connector on the Heat Exchanger labeled Control is connected to the Plumbing Control connector on the rear of the Cool Module using the extension cable provided.

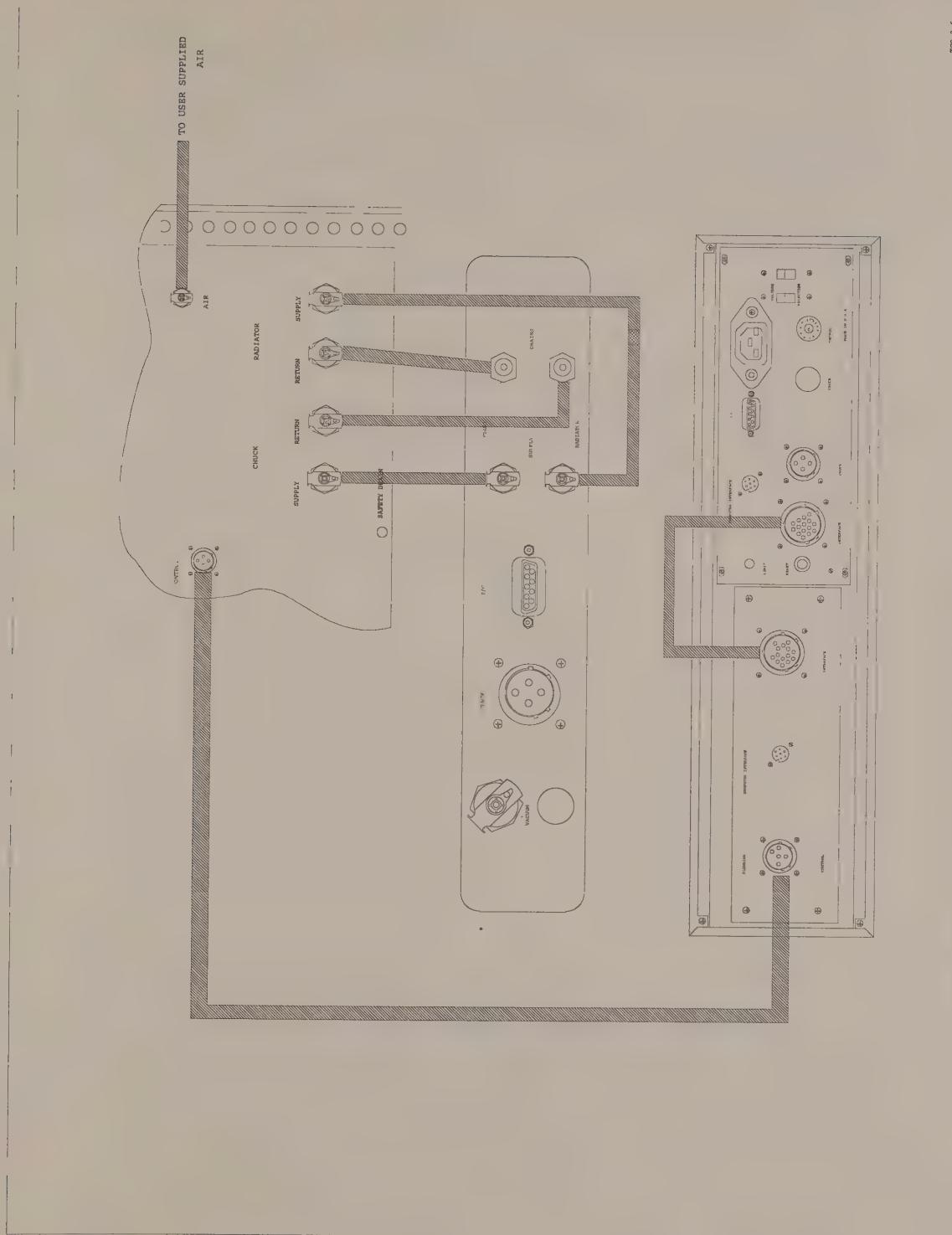


FIGURE 2-6. AMBIENT COOLING OPTION WITH HEAT EXCHANGER HOOKUP

2.2.5 ZERO °C Cooling Option (C1000-V1-C-0, C1000-V2-C-0)

The C1000-V1-C-0 and C1000-V2-C-0 cooling options includes a Service Module (SRV1) and a self contained chiller which provides a reservoir of cool liquid for use in cooling the chuck surface and radiator. The Cool Module is factory installed in the cabinet with the heat controller. The interface connection between the heat and cool controllers should also have been made at the factory. The user setup requires the hookup of the chiller and the SRV1 to the probe station and to the Cool Module.

PREPARATION:

The chiller supplied with the system is shipped empty and needs to be filled with a suitable cooling fluid. A gallon of commercial grade anti-freeze is included with the zero degree chiller. Using about 1 quart of anti-freeze and adding water to fill the reservoir will result in an appropriate water/glycol mixture. The fill port is located on the top of the chiller. Remove the clear plastic cover to fill the reservoir.

HOOKUP: (Ref. Fig. 2-7 for Unit Panel Locations)

There are six hoses supplied with the C1000-V1-C-0 and C1000-V2-C-0 cooling options. Refer to Figure 2-8 for system hookups. The yellow polyethylene hose is used to connect the SRV1 Chuck Assembly Supply to the Chuck Supply on the rear of the probe station. The blue polyethylene hose is used to connect the SRV1 Radiator Supply to the Radiator Supply on the rear of the probe station. The two red silicone hoses are used to connect the Chuck and Radiator drains from the probe station to the two drain connections on the rear of the chiller. The red polyethylene hose is use to connect the chiller supply to the water inlet on the SRV1. The clear polyethylene hose is use to connect the user supplied air to the air inlet on the SRV1. The connector on the SRV1 labeled Plumbing Control is connected to the Plumbing Control connector on the rear of the Cool Module using the extension cable provided.

2.2.6 Linear DC Power Source (DC-100)

The linear DC power Source (DC-100) is included with H1000-DC1-V1 and H1000-DC1-V2 H1000 Thermal Chuck Systems. The DC-100 is integrated with the heat controller at the factory during assembly. Please contact the factory for upgrade information if DC chuck power is desired.

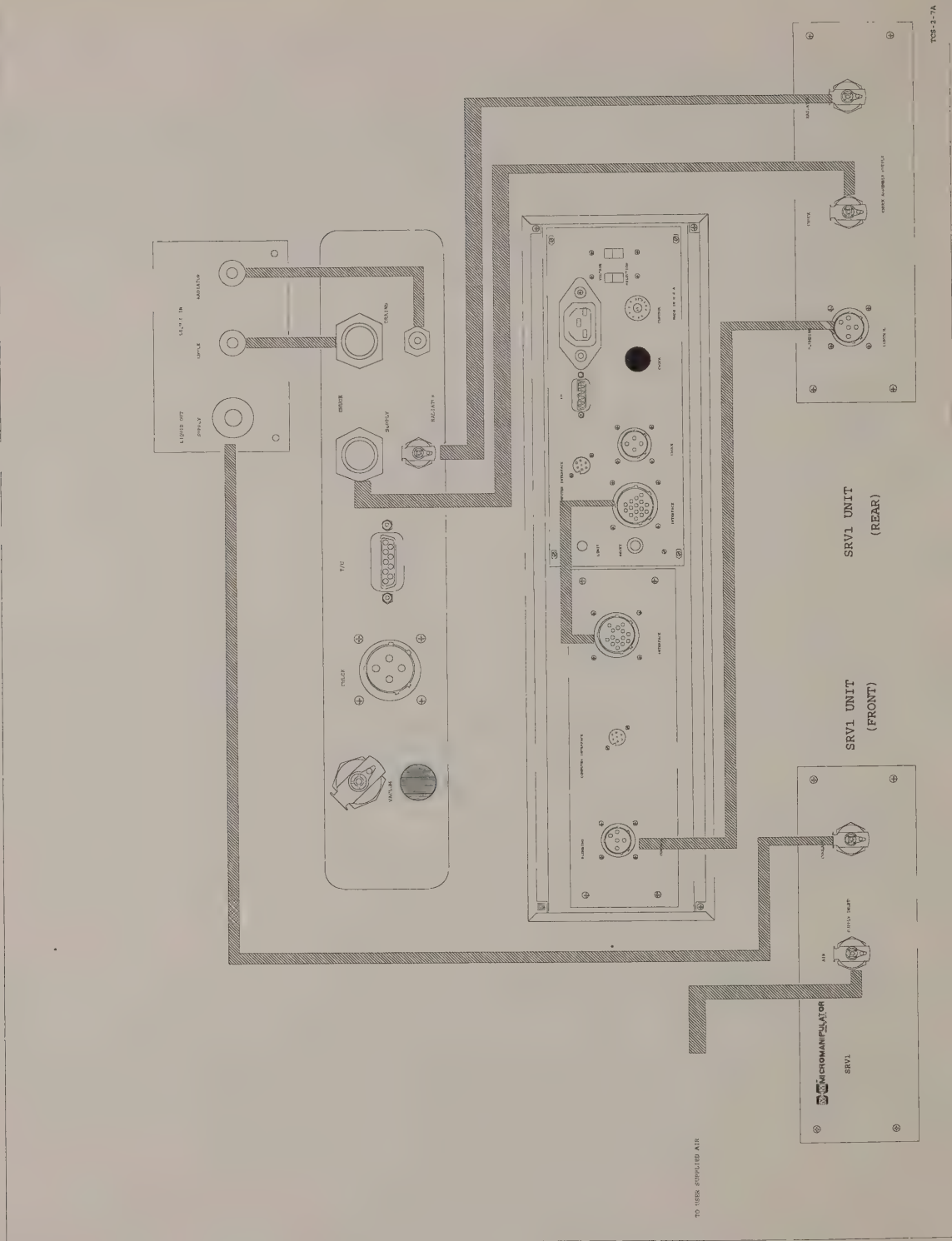


FIGURE 2-8. ZERO °C COOLING OPTION HOOKUP

2.2.7 Computer Interfaces (H1000-RS-232, H1000-IEEE, H1000-RS-422)

Each of the three computer interface options are connected to the H1000 heat and cool controllers via the two 7 position Viking connectors on the rear of each controller. The H1000-RS-232 and H1000-IEEE are each packaged in the same size chassis with the appropriate connectors mounted on the front panel. Each of the three interface options include two 10 ft cables with Viking plug connectors on each end.

NOTES

SECTION 3.0 OPERATING INSTRUCTIONS

3.1 INTRODUCTION

This section will be dedicated to the explanation and description of the controls and indicators associated with the HEAT CONTROLLER, COOL MODULE, CHILLER, and the DC100 POWER SUPPLY. It will also carry the user through a complete power up sequence.

3.2 HEAT CONTROLLER OPERATING MODES

There are two type of operating modes - MANUAL and COMPUTER control. Manual control is performed by the operator utilizing the controls on the front panel of the HEAT CONTROLLER. Computer control is performed by the HOST COMPUTER via a COMPUTER INTERFACE option.

3.3 POWER UP SEQUENCE



CAUTION: *Ensure that the Thermal Chuck is fully connected to system prior energizing, and conversely ensure that the Controller is turned off prior to disconnecting the Thermal Chuck assembly from system.*

To turn on the HEAT CONTROLLER, actuate the large square button labeled **POWER**. If the system includes a **DC100** option, turn this unit on also by placing its **POWER** switch to the **ON** position. When the HEAT CONTROLLER is switched on, the white **POWER ON** indicator (within the switch) should illuminate and the green **STOP** indicator should also be lit. If a COOL MODULE is part of the system, you will also see the green **PURGE** indicator (within the switch) light. A thirty (30) second purge will be initiated whenever the HEAT CONTROLLER is energized. Both the HEAT CONTROLLER and the COOL MODULE temperature displays should illuminate within five (5) seconds after the units are turned **ON**. The HEAT CONTROLLER will be in the **STOP** or idle mode.

***** **IMPORTANT - PLEASE READ** *****

Operation of the H1000 Thermal Chuck system under remote (computer) control can result in Heat or Cool operation when the system is turned on. In this case, the STOP indicator will illuminate, but the system will be in either Heat or Cool operation as indicated by the ACTIVE indicator flashing on either one of the controllers. Please refer to section 3.7 for a complete explanation of remote control operation.

3.4 HEAT CONTROLLER - CONTROLS AND INDICATORS

The HEAT CONTROLLER front panel (Ref. Fig. 3-1) is designed into two sections. These two sections are the actuation controls section (on the right side [flat face] of the panel) and the temperature displays section (on the left side [raised area] of the panel)

3.4.1 Heat Controller Actuation Controls and Indicators Section

The actuation control switches that initiate all actions of the controller in the manual mode and indicators operate as follows:

POWER: The **POWER SWITCH** applies or removes all power to the HEAT CONTROLLER. If you have a cooling option, this switch also enables all power to the COOL MODULE through the INTERFACE connector. To turn on the HEAT CONTROLLER actuate the large square button labeled POWER. If the system includes a DC100 option then turn this unit on also by placing its **POWER** switch to the **ON** position. When the heat controller is switched on the white **POWER** (switch) light should illuminate and the green STOP indicator should also light. If the system is equipped with a cooling option then you will also see the green **PURGE** (switch) light illuminate on the COOL MODULE. A thirty (30) second purge will be initiated whenever the controller is energized. The controller temperature displays should illuminate within five seconds after the controllers are turned on.

STOP: Depressing the **STOP** switch places the controller in an idle state. If the controller was in a **HEAT** operation, depressing the STOP switch disconnects the Thermal chuck from the power supply driving its heating elements and the **ACTIVE** light will stop flashing. The temperature displays will continue to operate normally. If the controller was in a **COOL** operation, depressing the **STOP** switch disconnects the Thermal chuck cooling coils from the coolant being supplied. A thirty second **PURGE** will be automatically initiated to remove the coolant from the THERMAL CHUCK assembly. The **ACTIVE** light on the COOL MODULE stop flashing.

HEAT: Depressing the **HEAT** switch initiates the "heat" of operation which controls the THERMAL CHUCK temperature above ambient. The green HEAT indicator will illuminate and the controller will begin delivering and controlling power to the THERMAL CHUCK. The associated display and setpoint control section temperature should begin exhibiting a small red flashing light labeled **ACTIVE** and the Chuck temperature display (green display) should also exit an increasing temperature until the setpoint temperature is reached. As the controller converges upon the setpoint the rate of **ACTIVE** flashes will diminish. If the system includes a DC100 option then its front panel meters will display the power that

the system is delivering to the Thermal chuck. The controller will stay in this "heat" mode until either the **COOL** or **STOP** switch is depressed.

COOL: Depressing the **COOL** switch causes the **COOL** light to energize. If the controller was in the **STOP** mode, depressing the **COOL** switch causes the **STOP** light to extinguish and the **COOL** light to energize. The **COOL** operation is the same as the **STOP** mode control if no COOL MODULE is present. If a COOL MODULE is installed depressing the **COOL** switch also initiates the Cool module controller functions. The COOL MODULE will begin controlling coolant flow to the THERMAL CHUCK to lower its temperature to its setpoint. The **ACTIVE** light will begin flashing on the COOL MODULES display face. Once the COOL MODULE setpoint is reached the controller stops the flow of coolant, and a thirty second **PURGE** is initiated to remove the coolant from the THERMAL CHUCK assembly. The **ACTIVE** light on the COOL MODULES temperature display face will stop flashing.

If the controller was in **HEAT** control, depressing the **COOL** switch disconnects the Thermal chuck from the power supply driving its heating elements. The **HEAT** light will extinguish and the HEAT CONTROLLER **ACTIVE** light will stop flashing.

NOTE

If your system does not have a COOL MODULE, pressing the COOL switch or pressing the STOP switch will discontinue the HEAT operation.

When a Cool module is present, depressing the **COOL** switch causes the **COOL** light to energize and initiates the Cool module controller functions. The COOL MODULE will begin controlling coolant flow to the THERMAL CHUCK to lower its temperature to its setpoint. The **ACTIVE** light will begin flashing on the COOL MODULES display face. Once the COOL MODULE setpoint is reached the controller stops the flow of coolant, and a thirty second **PURGE** is initiated to remove the coolant from the THERMAL CHUCK assembly. The **ACTIVE** light on the COOL MODULES temperature display face will stop flashing. If the THERMAL CHUCK's temperature increases above the setpoint, the controller will reroute coolant to the THERMAL CHUCK until the setpoint is reached again and the same purging process will reoccur.

3.4.2 Temperature Display Section

The temperature display section is the raised face element of the front panels. The temperature display section of each controller module has two displays, a green display which is the actual

temperature currently being measured and a red display that indicates the controllers current temperature setpoint. This section also contains flush membrane control switches for controlling the displays. These membrane switches posses very good tactility for operator feedback when using them. There are three outlined switches two with arrows on them and one labeled **DSPY MODE**. There are also two hidden (non outlined) switches used for special functions only or for reestablishing proper controller operation if the system is setup or disconnected improperly.

The setpoint is adjusted by the two arrows on the right hand side of the raised front panel face of the controller. The arrow pointing upwards increases the temperature setpoint and the arrow pointing down lowers the temperature setpoint. Familiarize yourself with their operation by changing the setpoint to a variety of values. The longer the arrow is held depressed the faster the temperature settings will change. The display on the HEAT CONTROLLER is used for setting the high temperature or **HEAT** setpoint, and the display on the COOL MODULE is used for setting the low temperature or **COOL** setpoint.

The **DSPY MODE** switch when depressed cycles the lower red display between a series of programmed information. Normally the red display is the Temperature setpoint. Press the **DSPY MODE** switch once and the display indicates the deviation in degrees that the THERMAL CHUCK temperature is from the controllers setpoint temperature. A red lamp next to **DEV** will light at this time. Depress this switch a second time and the display will indicate the amount of power or controller output is being supplied to make the chuck reach its setpoint temperature from its current temperature. A red lamp next to **% OUT** will be lit at this time. Depress this switch a third time, and the red display will show whether the temperature is being displayed in degrees C or F. The shipping default is degrees C. Depress this switch a fourth and final time to return this display to normal (setpoint temperature).

One hidden switch (and hidden indicator) is located between the down arrow button and the **DEV/%OUT** indicators. This switch allows the user to place the controller in a % output control instead of a temperature setpoint control. This is an advanced feature not fully available to most end users but will be covered under operating modes. This switch must be used to reset the proper controller functions if the system is setup, started up, or shutdown improperly (Theory of operation section and troubleshooting section).

The second hidden switch is located between the up arrow button and the **DSPY MODE** outline. It is used strictly for factory setup of the controllers (Theory of operation section and troubleshooting section).

% OUTPUT: These controllers can be altered to allow the Chuck to be driven in a mode not dependent of a temperature setpoint. The hidden switch on the temperature display section of the controllers provide the user with that advanced control function. Since this is an advanced feature it is not fully available to most end users with out special arrangements being made with **TMMCO**. When the controller senses an open Temperature sensor (or it is disconnected) the controller defaults into the % Output mode with the default % corresponding to no output for that controller. The HEAT CONTROLLER and the COOL MODULE faults

to 0 % output which equates to **OFF**. When the temperature sensors are reconnected the temperature controllers will resume their initial controlling function. This allows very temporary disconnection of the temperature sensors without resetting the controllers. However if the Temperature sensors are disconnected for more than 12 seconds, the second (redundant) safety controller will disconnect the Thermal Chucks heating elements from the power supply. If this occurs then the HEAT CONTROLLER's power must be cycled off and back on again to reset it. An alternative to cycling the power on the HEAT CONTROLLER to reset the safety temperature controller is actuating the **RESET** switch located on the HEAT CONTROLLER rear panel under the red **LIMIT** light. More about this feature under theory of operation section of this manual and the troubleshooting section of this manual.

If the controller is turned off while the temperature sensors are disconnected, the Controllers will default too this 0 % output if the temperature sensors are reconnected prior to turning the controllers back on. The **% OUT** light will be lit and a light indicating the location of the hidden button will also be lit under these circumstances. To place the controllers back into proper operation depress the hidden button twice. This will extinguish the hidden button light and return the controllers back to normal temperature setpoint control.

If the controller is turned off while the temperature sensors are disconnected and then turned back on before reconnection, the Controllers will default to normal temperature setpoint control after the temperature sensors are reconnected.

3.5 COOLING OPTIONS

Each of the different cooling options includes a COOL MODULE. The COOL MODULE controls and indicators are the same for all cooling options.

The COOL MODULE front panel (Ref. Fig. 3-1) is also designed into two functional sections. The actuation controls section reside on the main flat face portion of the panel. The display and setpoint controls are found on the raised face section of the front panel.

The only separate actuation control associated with the COOL MODULE is the **PURGE** switch. The **PURGE** switch is similar to the **POWER** switch on the HEAT CONTROLLER. It is a two position latching push-button switch. It is actuated by depressing it. If the switch is in the elevated position and depressed it latches in the depressed position. When the switch is depressed again the latch is released and the switch will return to its elevated position.

Each of the different cooling options perform automatic purging functions under specific conditions. The **PURGE** switch allows the user to perform a purge at any time by depressing the switch **PURGE** switch.

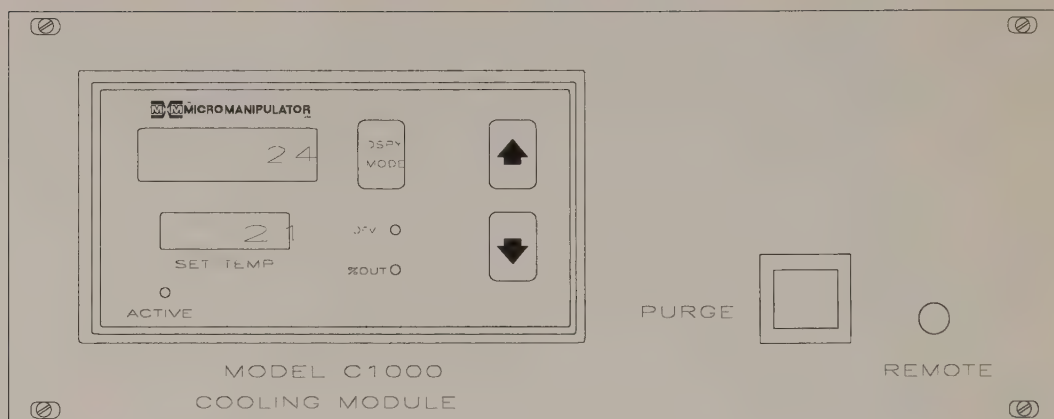


FIGURE 3-1. COOL MODULE FRONT PANEL

PURGE: The COOL MODULE front panel is also designed into two functional sections. The actuation control section resides on the main flat face portion of the panel, and the display controls are found on the raised face section of the front panel. The only separate actuation control associated with the COOL MODULE is the **PURGE** switch. The **PURGE** switch is similar to the **POWER** switch on the Heat Controller. It is a two position latching push-button switch with a built in lamp. It is actuated by depressing it. If the switch is in the out (**OFF**) position and depressed, it latches in the in or depressed (**ON**) position and the lamp will light. When the switch is depressed again the latch is released and the switch will return to its out (**OFF**) position and the lamp will extinguish. When the **PURGE** switch is turned on (latched in the in or depressed position) the PURGE (switch) light illuminates and the remote valve controlling the air delivery to the THERMAL CHUCK is energized. This condition is maintained until the **PURGE** switch is actuated back to its **OFF** (out) position (off). **PURGE** can be initiated regardless of what mode the controllers are in (**HEAT**, **COOL**, or **STOP**).

This is particularly useful when insuring that all coolant is removed from the chuck for greater isolation.

NOTE:

*The **PURGE** (switch) lamp will be lit anytime the switch is on, or that the Purge interval timer is energizing the remote valve controlling the air delivery to the THERMAL CHUCK.*

3.5.1 TEMPERATURE DISPLAY SECTION: Reference section 3.4.2 for description.

3.5.2 ZERO °C Cooling Option (C1000-V1-C-0, C1000-V2-C-0)

This cooling option includes a chiller to supply a cooling fluid to the thermal chuck system. The chiller power is turned on after the HEAT CONTROLLER is turned on. Turn the chiller power switch on. Verify that the amber indicator is ON.

For zero degree operation, it is suggested that the set point be adjusted to -10° C. For cooling to other temperatures between 32° C and 0° C, adjust the set point between 5 and 10 degrees below the desired cool temperature. The set point is adjusted by pressing and holding the up or down arrow button on the chiller top panel.

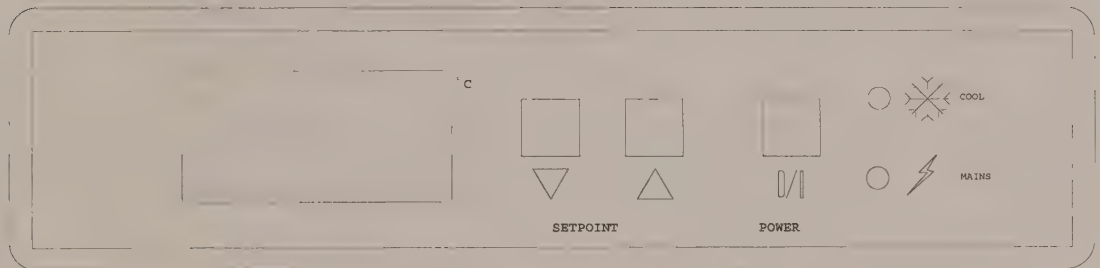


FIGURE 3-2 ZERO °C CHILLER FRONT PANEL

3.6 LINEAR DC POWER SOURCE (OPTIONAL)

The only user controls and indicators associated with the DC100 option (Ref. Fig. 3-3) is one **POWER** switch and two meters. The **POWER** switch is two 20 amp circuit breakers linked together on the front panel as one two position single throw switch. When placed in the up position labeled ON the power is turn on. When the switch is placed in the down position labeled **OFF** the power supply is turned off. The two front panel meters are one **DC VOLT** meter and one **DC AMPERES** meter. They are used to monitor the power supplied to the THERMAL CHUCK. When the power supply is turned on the The user will be able to here the sound of the cooling fans inside of the power supply. The HEAT CONTROLLER must be in the **HEAT** mode before any deflection of the panel meters will occur.

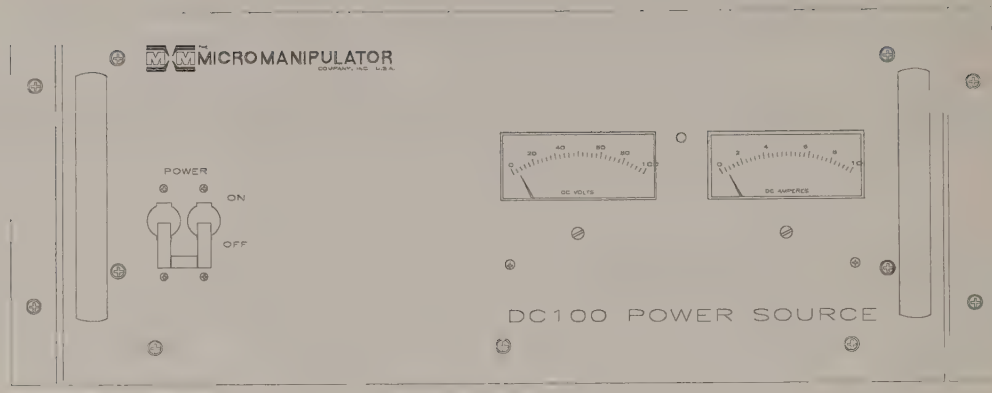


FIGURE 3-4. DC100 POWER SUPPLY FRONT PANEL

3.7 REMOTE CONTROL OPERATION

Both the Heat Control Module and the Cool Module have provisions for remote control via RS-422. Communications converters are available which will accept an RS-232 or GPIB (IEEE-488) interface to the RS-422 ports.

The command set for the H1000 Thermal Chuck System can be found in Appendix A. Users may develop their own software to control the system. Micromanipulator has developed a software package called pcTC which provides both manual and sequential control of the H1000 Thermal Chuck System to include a DDE interface to other applications running such as pcProbe II and ICS.

When the Heat Control Module and Cool Module receive a communications instruction to perform a function (such as HEAT), the command is executed until a communications instruction is received to perform some other function. The last instruction received by the Heat and/or Cool Module is "remembered" and will continue to be performed even after power is turned OFF and ON. This feature can be very cause system operation which may appear to be a malfunction. If the Heat or Cool Module is ACTIVE when power is applied, then the system is most likely responding to a previously sent command. The only way to correct this situation is establish communications with the controller and send an instruction to STOP, and exit the program normally.

NOTE: The HEAT and COOL are operational even when the system is under computer control. Therefore, the system could be BOTH heating and cooling at the same time if the system received an instruction to COOL and the HEAT button was pressed. To avoid this condition from occurring, make sure that the STOP indicator is illuminated when the system is being controlled by through remote communications.

3.8 ERROR CODES AND INDICATIONS

When either the heat or cool controller senses an error or fault, the green temperature indicator will display "- - - -" 4 dashed lights, the red display will indicate 0, the hidden switch light illuminates, the front panel REMOTE lamp lights, and the mode light (HEAT, COOL, or STOP) that was on will remain on. The controller defaults into the % OUT mode with the default % corresponding to no output for that controller. The controllers outputs will turn off. To view the error code press the hidden button indicated by the light once. The upper display will show the error code for 5 seconds before returning to the "- - - -" display.

E1 1 - A/D underflow error

A reversed polarity sensor is the most likely cause of this error. A mismatched sensor to controller can also provide this error. Open sensors can also cause this error when RTDs are used. Check the sensor; if the connection is good and functions properly, call the factory.

E1 2 - Sensor under-range error

The sensor generated a value lower than that allowed for the range of that sensor or the A/D circuitry failed. Controller inputs are matched to the sensors incorporated into the thermal Chucks for that system. Call the factory.

E1 3 - Sensor over-range error

The sensor generated a value higher than that allowed for the range of that sensor or the A/D circuitry failed. Controller inputs are matched to the sensors incorporated into the thermal Chucks for that system. Make sure you controller is set up for the sensors in your system. Call the factory.

E1 4 - A/D overflow error

This condition could be caused by an opened temperature sensor. Check to see that the sensors are connected to the system. Call the factory.

NOTE:

Reconnection of the sensors in under 12 seconds will return the controllers back to normal operation. If it takes longer than this to reconnect the temperature sensors then a second safety controller will activate a rear panel LIMIT light and disconnect the Thermal Chuck from the heater power supply. The second safety controller can be reset by actuating the rear panel reset button or by cycling the power to the controller (power on reset).

Er 3 - Ambient temperature error

The ambient temperature of the controller has dropped below 32 °F / 0 °C or risen above 149 °F / 65 °C. Correct or call the factory.

(*)Er 4 - RAM verification error

Displayed when an internal RAM failure has occurred. Call the factory This error may be cleared by cycling power to the controller, however this error will alter the controller's default values.

(*) Er 5 - Non-volatile checksum error

Displayed when an EEPROM checksum error has been detected. Call the factory.

(*)Er 9 -

Call the factory.

(*) Error codes Er4, Er5, and Er9 will result fault the controllers in these conditions:

The green display will display the error code.
The bottom display will be blank.
The controller outputs will turn off.
The remote lamp on the front panel will light.

More error codes are available with computer communications and those error codes are listed in this manual, APPENDIX A - COMPUTER COMMANDS.

SECTION 4.0

PRINCIPLES OF OPERATION

4.1 INTRODUCTION

This section will discuss the **PRINCIPLES OF OPERATION** of the individual components that comprise the **H1000 THERMAL CHUCK SYSTEM** as well as the overall operation when these components are working in concert.

The most basic H1000 Thermal Chuck System consists of two components; the **Thermal Chuck** and **Heat Control Module**. Optional equipment include one of three **Cooling Options**, one of three **Computer Interfaces**, and a **Linear DC Power Source**.

4.1.1 Thermal Chuck

The Thermal Chuck Assembly is divided into four elements:

- 1) the "PUCK" (Temperature controlled surface)
- 2) the radiator
- 3) the kinematic mounting of the "PUCK" in the assembly
- 4) the isolation surface (on XC and T models only)

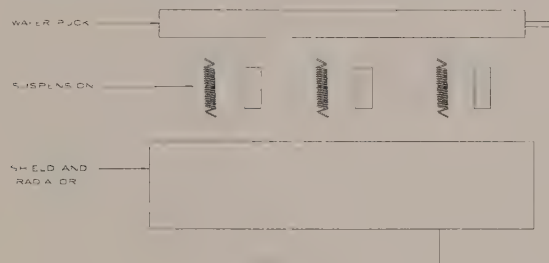


FIGURE 4-1. THERMAL CHUCK

4.1.2 Heat Control Module

The **Heat Control Module** is broken into six main elements or sub-systems:

- 1) the operator controls (front panel)
- 2) equipment interfaces (rear panel)
- 3) power on reset circuit
- 4) main temperature controller
- 5) second safety (back up) temperature controller
- 6) heater isolation relays

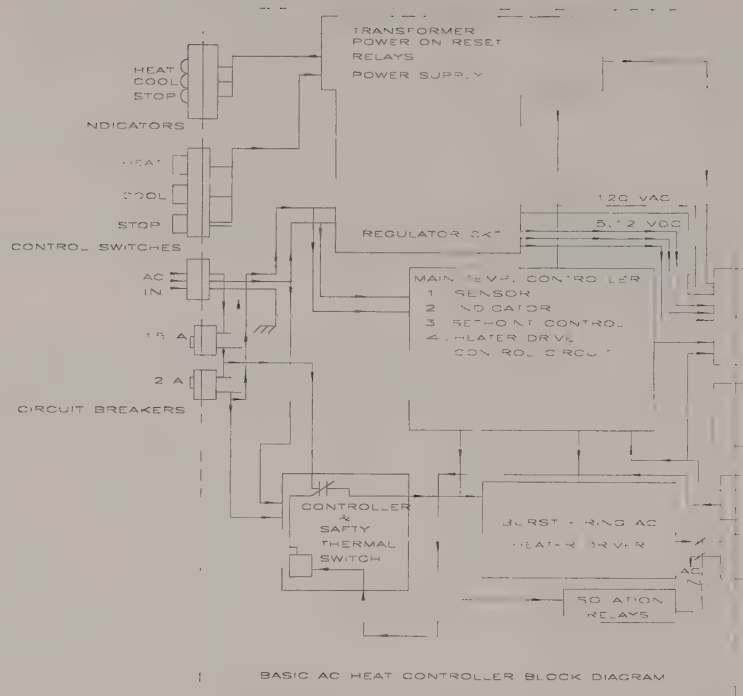


FIGURE 4-2. HEAT CONTROL MODULE BLOCK DIAGRAM

4.1.3 Linear DC Power Source (Optional)

The **Linear DC Power Source** (DC-100) consist of three main elements or sub-systems:

- 1) the AC input
- 2) the DC supply
- 3) the output control (and display) circuits

4.1.4 Cooling Options

Each of the different **Cooling Options** includes a **Cool Module** which is installed in the same chassis as the **Heat Control Module**. Refer to Figure 4-3 for a block diagram of the **Cool Module**.

AMBIENT COOLING OPTION (C1000-V0-H)

The elements of the C1000-V0-H COOLING OPTION are:

- 1) **Cool Module**
- 2) **Service Module** (SRV1)
- 3) Various hoses and interconnection cables

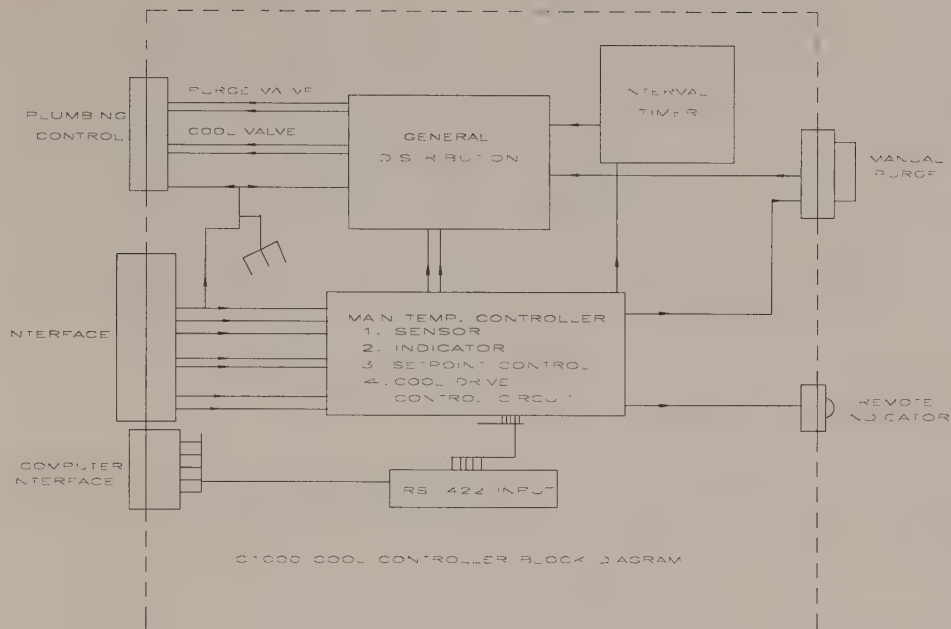


FIGURE 4-3. COOL MODULE BLOCK DIAGRAM

AMBIENT COOLING OPTION (C1000-V1-HE, C1000-V2-HE)

The elements of the C1000-V1-HE, C1000-V2-HE COOLING OPTIONS are:

- 1) **Cool Module**
- 2) **Heat Exchanger**
- 3) Various hoses and interconnection cables

ZERO DEGREE C COOLING OPTION (C1000-V1-C-0, C1000-V2-C-0)

The elements of the C1000-V1-C-0, C1000-V2-C-0 cooling options are:

- 1) **Cool Module**
- 2) **Zero Degree C Chiller**
- 3) Various hoses and interconnection cables

4.1.5 Computer Interfaces (Optional)

The **H1000 Thermal Chuck System** can be controlled using a remote computer via one of the three optional interface options.

RS232 INTERFACE (H1000-RS-232)

The H1000-RS-232 interface includes a converter module and cables which converts the native RS-422 interface for each of the controllers and accepts a RS-232 communications link using ANSI X3.28 protocol.

IEEE-488 INTERFACE (H1000-IEEE)

The H1000-IEEE interface includes a converter module and cables which converts the native RS-422 interface for each of the controllers and accepts a IEEE-488 (GPIB) communications link.

RS-422 INTERFACE (H1000-RS-422)

The H1000-RS-422 interface includes the necessary cables to interface the heat and cool modules to a RS-422 controller. The RS-422 communications protocol is native to the H1000 control modules.

4.2 THERMAL CHUCK

The H1000 THERMAL CHUCK has been specially designed and fabricated for high performance applications in probe stations.

4.2.1 Thermal Chuck Construction

The Thermal Chuck (PUCK) temperature controlled wafer surface is made from an aluminum casting. This part has isolated heater elements and cooling tubes cast directly in the PUCK in a proprietary pattern. This special casting insures rapid heating and cooling as well as extremely even temperature distribution (better than 1 °C.).

The wafer surface is machined flat to .0002" and then sputtered coated with platinum. This process ensures an electrically conductive, chemically inert wafer interface that remains extremely flat even at highly elevated temperatures.

Several temperature sensing devices are imbedded into the PUCK to ensure accurate temperature measurements. These devices include:

- 1) 2ea 3-wire platinum resistance temperature sensing devices (RTD's)
- 2) 2ea type "K" thermocouples

The RTD's are used by the **Heat Control Module** and the **Cool Module** to monitor the temperature of the thermal chuck. One thermocouple is used to monitor temperature for the

overtemperature circuit and the other thermocouple is a spare device. Since the sensing device is inside the PUCK, the operator is sure of the actual temperature at the wafer (interface) surface.

Even though the heater elements and temperature sensors are imbedded in the cast PUCK, they are electrically isolated from the PUCK's surface. The PUCK is also electrically isolated from the rest of the assembly by a special kinematic suspension system. This suspension system minimizes the effects of thermal expansion and contraction of the PUCK's wafer surface while maintaining high electrical isolation by using either Pyrex or sapphire suspension rods and springs anchored in Teflon.

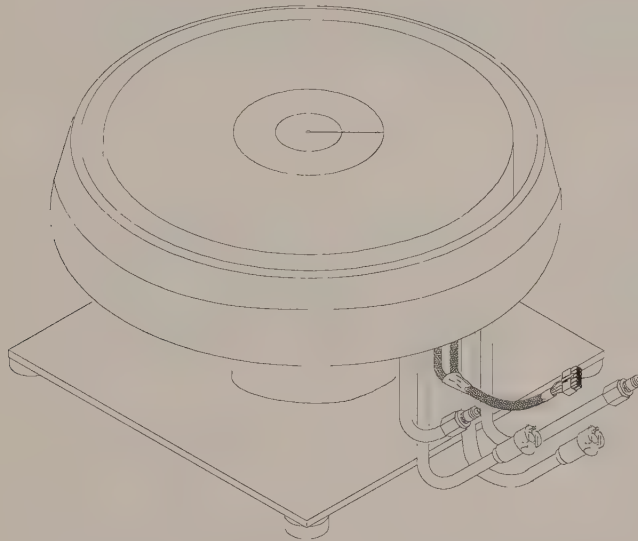


FIGURE 4-4 THERMAL CHUCK

The **Thermal Chuck** is equipped with an outer radiator which provides both an electrical and thermal shield. The cooling radiator serves two purposes:

- 1) to minimize the danger to personnel who might inadvertently come in contact with the outside of the THERMAL CHUCK assembly when it is at an elevated temperature
- 2) to prevent damage to the X - Y stage mechanism from heat radiated down into the probe station.

NOTE

Advanced Coaxial and Triaxial thermal chuck assemblies have removable circuit elements made from 99.5% pure alumina oxide (Al_2O_3). This material was selected for its excellent electrical

isolation properties while providing very good heat transfer properties. The design for indexing these circuit elements to the heat and cooling engines (puck) of the chuck assembly must allow for the large differences in thermal expansion rates between these parts. Accordingly, these parts have manufacturing tolerances that allow for thermal motion differences while maintaining superb thermal conductivity. Inherent to this design are minuscule vacuum leakage paths. The Chuck assemblies are checked to ensure aberrant leakage does not exist and that wafers are adequately held down when vacuum is applied. The typical vacuum deviation for these assemblies is 2" to 4" of mercury when connected to a vacuum source with a minimum rating of 20" Hg@0.5 CFM.

4.2.2 Temperature Sensing

As mentioned previously, each **Thermal Chuck** has temperature sensing devices imbedded within the cast PUCK. Each PUCK has two **RTD** type temperature sensing devices along with a separate safety thermocouple that goes directly to a second safety thermocouple control circuit in the **Heat Control Module**. Each PUCK also contains a second spare type K thermocouple.

Each PUCK's temperature sensors are calibrated with the controllers at the factory to ensure good thermal stability throughout the PUCK as well as accurate control.

When the temperature sensors are inserted into the PUCK, they are potted in a proprietary fashion to ensure a high volume of resistivity of a teraohm or greater at ambient temperature. However, more importantly, at very high temperatures the isolation numbers also stay extremely high.

4.3 HEAT CONTROL MODULE

The **Heat Control Module** can be broken down into six (6) elements or sub-systems working independently and/or in concert to maintain a selected temperature for the THERMAL CHUCK assembly. These elements or sub-systems are:

- 1) operator control panel (Front Panel)
- 2) equipment interface (Rear Panel)
- 3) power on reset circuit
- 4) main temperature controller
- 5) safety temperature controller
- 6) heater isolation relays

4.3.1 Heat Control Module Front Panel

The function of the Heat Control Module (Ref. Fig. 4-2) is control the temperature of the Thermal Chuck when the H1000 system is in HEAT mode. The Heat Control Module has a dedicated front panel for operator control and input. The Heat Control Module front panel operation is described in Section 3.4 of this manual.

4.3.2 Equipment Interface (Rear Panel)

The **Equipment Interface** (Rear Panel) provides all necessary interface connections between the **Heat Control Module** and other modules in the **H1000 THERMAL CHUCK SYSTEM**. These connections include the **INTERFACE**, **COMPUTER INTERFACE**, **CHUCK** and **T/C** connectors.

INTERFACE CONNECTOR

The **Interface Connector** is used to connect the **Heat Control Module** directly to the **Cool Module** when there is no **Linear DC Power Source** connected to the system. When the **Linear DC Power Source** is connected to the system, the **Heat Control Module** is connected to it via a "Y" cable with one leg of the cable going over to the **Cool Module**.

COMPUTER INTERFACE CONNECTOR

This connection allows the **Heat Control Module** to be controlled by a host computer control. The native control communications is RS-422. Converters are available which will accept RS-232 or IEEE-488 communications.

CHUCK CONNECTOR

This connector provides connection from the HEAT MODULE to the THERMAL CHUCK assembly via the connector on the rear of the probe station.

T/C CONNECTOR

This connector provides connection between the HEAT MODULE and the THERMAL CHUCK assembly's appropriate temperature sensing devices via the connector on the rear of the probe station.

4.3.3 Power On Reset Circuits

The HEAT CONTROLLER has three circuits which ensure that the controller is reset properly when power is cycled.

MANUAL CONTROL

These circuits are designed to ensure **Power On Reset** when the system experiences a loss of power. When power is re-applied to the system, the **Power On Reset** circuits brings the **Heat Control Module** back up to last operation it was performing. This condition is the **STOP** (or idle) state.

SPECIALIZED POWER SUPPLY

The **Heat Control Module** also houses a separate power supply used to control isolation relays and other special functions.

One of its special functions is to control a **TIMING RELAY** for the isolation relays. This timing circuit allows the isolation relay to shut off when the system is placed in the **HEAT** mode prior to sending a control signal the **Linear DC Power Source**.

When the **HEAT** operation is halted, the timing circuit will operate to ensure that the relays are energized until after the control signal is removed from the **Linear DC Power Source**.

These functions have been designed to ensure that no large transient currents are operating through the relay contacts. By doing this, the life of the relay contacts will be prolonged. This will also minimize transient noise associated with the relays opening and closing with large currents going through them. This should not become a problem because the load is purely resistive; however, any such action across the relay contacts will cause noise spikes.

4.3.4 Main Temperature Controller

The **MAIN TEMPERATURE CONTROLLER** is part of the operator interface located on the front panel. This is a modular component that can be removed and replaced by service personnel at any time if it is damaged or fails.

This base system (under **PID** control) is designed to go from ambient to 400 °C. The **PID** control has been optimized for operation at 300 °C. If the end user knows of a specific temperature at which the system will be operating and that temperature is less than 300 °C, the **PID** controls can be reset. The factory can be contacted and service personnel can be sent to return the system for a specific temperature.

4.3.5 Safety Temperature Controller

When a **H1000 Thermal Chuck System** is ordered, the specific operating temperature of the system is determined by its specifications. A second temperature limit is set into the system at

the factory to ensure safe operation of the unit. The **Safety Temperature Controller** is designed to ensure that predetermined temperature is not exceeded.

This safety circuit is a second type of heat controller that acts as a backup safety temperature controller to the **Heat Control Module**. It monitors a separate temperature sensing device inside the PUCK that is set at a pre-determined temperature of approximately 25 °C above the factory set temperature or setpoint for the specified **Heat Control Module**.

EXAMPLE:

If the system's **Heat Control Module** operates at 210 °C, the **Safety Temperature Controller** will be set at 235 °C. If the **Heat Control Module** requirement is 400 °C, the **Safety Temperature Controller** will be set at 425 °C.

The **Safety Temperature Controller** is designed as a backup in the event of a sensor failure in the PUCK. If a thermocouple fails in the shorted condition, it appears as an ambient temperature to the **Heat Control Module**. Having two separate sensors monitored separately provides a redundant safety feature to protect the equipment as well as the end user.

On the rear panel of the **Heat Control Module** is a **RESET** switch with an indicator which allows the operator to determine if the **Safety Temperature Controller** has been activated due to a malfunction and needs to be reset.

NOTE

Due to the **Power On Reset** circuit, it is not necessary to go to the rear panel of the **Heat Control Module** to reset the **Safety Temperature Controller** -- just turn the **Heat Control Module OFF/ON** and all conditions will be reset.

4.3.6 Isolation Relays

The **Isolation Relays** are a set of relays that are placed in series between the power source and the **Thermal Chuck**. These relays, two FORM A type, are rated to handle 16 amps with a breakdown voltage in excess of 1000 VRMS.

4.4 COOLING OPTIONS

4.4.1 Ambient Cooling Option (C100-V0-H)

The C1000-V0-H cooling option consists of three (3) elements or sub-systems. They are:

- 1) **Cool Module**
- 2) **Service Module (SRV1)**
- 3) Plumbing accessories (hose and tubing assemblies)

COOLING MODULE

The C1000-V0-H is the most basic cooling option (Ref. Fig. 4-7 & 8) available. It allows the Thermal chuck to be connected to a coolant and air supply for a more rapid cooling of the thermal chuck. Its intended operation would allow rapid cooling to ambient with a subsequent purge of air to remove the coolant from the **Thermal Chuck** assembly. Its temperature set point range is 400 to 10° C. The C1000-V0-H cooling option consists of a **Cooling Module**, the SRV1, plumbing accessories such as tubing and quick connects, the appropriate INTERFACE cable and SRV1's plumbing control interconnecting cable.

The **Cooling Module** is designed to slide into the right hand side of the Heat Controller. On the front panel are the manual temperature set point controls, Chuck temperature display, and a manual PURGE control. The module has three rear panel connectors labeled: INTERFACE, COMPUTER INTERFACE, and PLUMBING CONTROL. The INTERFACE connector supplies the necessary power and control signals for the Cooling Module to be operated from the host Heat Controller. The PLUMBING CONTROL connector supplies the necessary control signals to the **Plumbing Service Module (SRV1)**. The COMPUTER INTERFACE connector is a seven position Viking connector wired to provide access for 422 serial control of the module or using RS-232, IEEE-488 with an appropriate interface option. Operation instructions for the Cooling Module can be found in section 3.X of this manual.

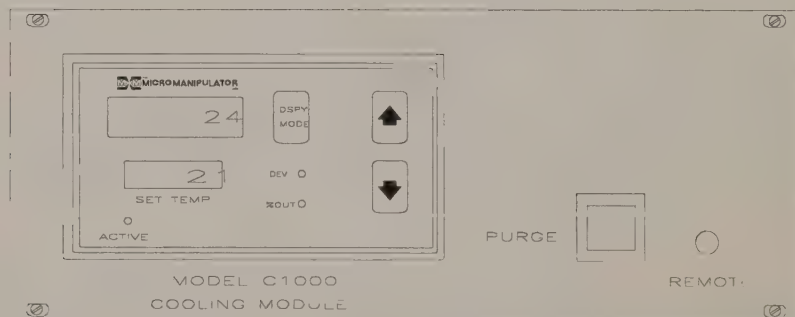


FIGURE 4-5. COOL MODULE (FRONT VIEW)



FIGURE 4-6. COOL MODULE (REAR VIEW)

THEORY OF OPERATION FOR A COOLING OPTION

When the COOL BUTTON is depressed on the **Heat Control Module**, a control signal is then transmitted to the **Cooling Module** which will begin a cool cycle to the preset temperature. The **Cooling Module** then sends a signal to the SRV1 MODULE to control and direct coolant to the **Thermal Chuck** assembly. It will continue to send coolant to the **Thermal Chuck** assembly until the temperature that was preset is obtained.

In ambient cooling option, it will discontinue the direction of the coolant flow and start a preset thirty second PURGE operation to remove the coolant from the **Thermal Chuck** in preparation for the next heat cycle.

In the Zero Degree C cooling option, coolant continues to flow and control the temperature of the thermal chuck to the set point on the Cooling Module. A PURGE operation will automatically be initiated only when the thermal chuck temperature transitions 1.5 °C over the set point on the Cool Module. If the user has any doubt if there is liquid in the chuck, a manual PURGE can be done using the PURGE button on the Cooling Module front panel.

The PURGE cycle is designed to remove the coolant from the PUCK to not only facilitate the next HEAT CYCLE but to also increase the electrical isolation of the **Thermal Chuck** assembly.

PLUMBING SERVICE MODULE (SRV1)

The **Service Module** (SRV1) is designed to allow for various types of cooling operations to service the **Thermal Chuck**. The SRV1 consists of a couple of control valves that direct coolant and air as necessary to allow the basic COOL operation. It directs a constant flow of coolant through the **Thermal Chuck** assembly radiator at all times. During the COOL operation, it also directs coolant through the **Thermal Chuck** PUCK.

At the end of a COOL cycle in ambient cooling options, it discontinues the coolant flow through the PUCK and replaces it with air, for thirty seconds, to remove any excess coolant remaining in the PUCK. The SRV1 is connected to the **Cooling Module**, via an interface cable, to transmit the control signal from the **Cooling Module** to the SRV1.

Zero Degree C cooling options maintain coolant flow in the thermal chuck to maintain the set point in the Cooling Module.

PLUMBING ACCESSORIES (Hose and Tubing Assemblies)

The hose assemblies are used to handle the higher temperature drain lines that exit the **Thermal Chuck** assembly. Special hoses and fittings are used that can handle these excess temperatures. The tubing assemblies are used to supply coolant to the **Thermal Chuck** assembly. The supply temperature will seldom, if ever, get above ambient.

Other plumbing accessories supplied are two ten foot lengths of tubing affixed with male quick connects on each end for interconnection of the SRV1 to the Prober. Also supplied are two fifteen foot lengths of 1/4" OD semi-rigid tubing, each with one quick connect, for connection of the SUPPLY INLETS of the SRV1 to the appropriate services. All plumbing quick connect fittings have internal shut off valves. The connection of tubing/hose to the SRV1 and the **Thermal Chuck** is fairly straight forward. The SRV1 module will have a plumbing diagram (Ref. Fig 4-7 & 8) of the hose assembly affixed to the top of the module cabinet for reference to make all of the proper connections.

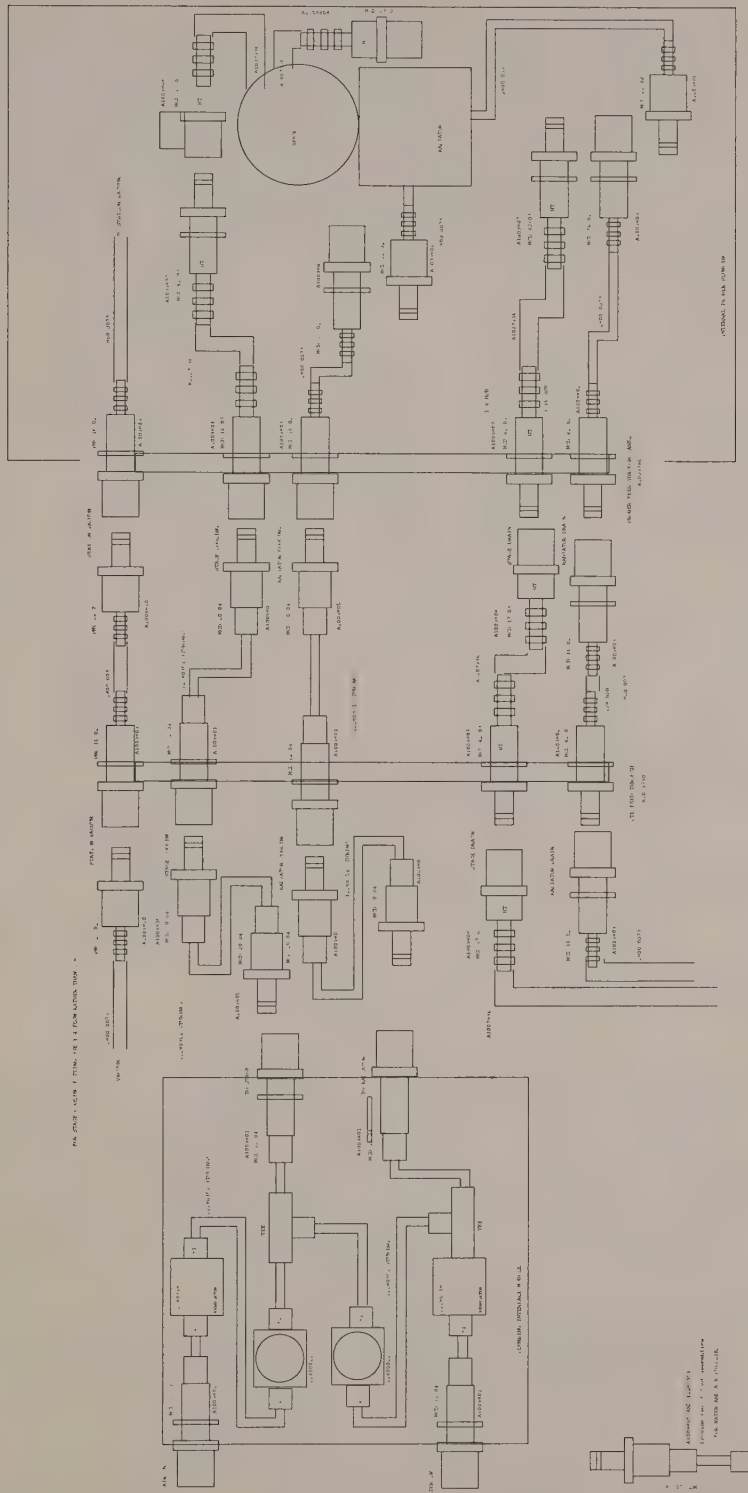
4.4.2 Ambient Cooling Option (C1000-V1-HE, C1000-V2-HE)

The C1000-V1-HE and the C1000-V2-HE cooling options consist of three (3) elements or sub-systems. They are:

- 1) **Cooling Module**
- 2) **Heat Exchanger**
- 3) Plumbing Accessories (hose and tubing assemblies)

The **Cooling Module** for this cooling option is the same as the C1000-V0-H cooling option as described earlier in this section.

Cooling Module for the



HEAT EXCHANGER

The **Heat Exchanger** is a self-contained unit which maintains the output cooling fluid at the same temperature as the ambient air. Liquid and air enter the exchanger at different temperatures and exit with shared temperatures. The resultant heat transfer is used to cool the liquid to a temperature that match the incoming air. The closed loop liquid cooling system is used to cool water or a water/glycol mixture as the coolant, heat is transferred from the system chuck cooling fluid through the exchanger where it is transferred to the air. The constant circulation removes the heat and rapidly cools the fluid to the 'Ambient' or incoming air temperature. Refer to Figure 4-9 for a flow diagram.

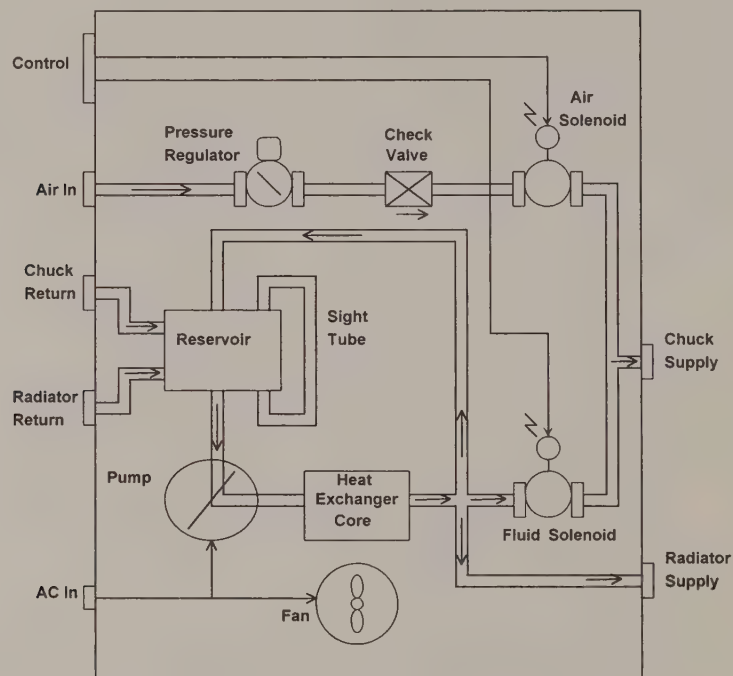


FIGURE 4-8. HEAT EXCHANGER FLOW DIAGRAM

4.4.3 Zero Degree C Cooling Option (C1000-V1-C-0, C1000-V2-C-0)

The C1000-V1-C-0 and the C1000-V2-C-0 cooling options consist of three (3) elements or sub-systems. They are:

- 1) **Cooling Module**
- 2) **Zero Degree C Chiller**
- 3) **Service Module (SRV1)**
- 4) **Plumbing Accessories (hose and tubing assemblies)**

The **Cooling Module** for this cooling option operates very similar to that used in the C1000-V0-H cooling option. The subtle difference between the two modules is in the way the

PURGE operates. The Zero Degree Cooling Module automatically initiates a PURGE only when the thermal chuck temperature rises 1.5 °C above the set point on the Cooling Module. The user should initiate a manual PURGE using the PURGE button on the Cooling Module front panel if there is any doubt whether the thermal chuck has liquid in it.

The SRV1 used in the Zero Degree Cooling Option is slightly different than the SRV1 used in the ambient cooling option. The zero degree SRV1 does not regulate the pressure to the chuck cooling, but does regulate the coolant pressure supplied to the radiator.

ZERO DEGREE C CHILLER

The **Zero Degree C Chiller** contains a refrigeration unit which maintains a reservoir of cooling fluid (normally water/glycol mixture) at a specific temperature set using the front panel. The SRV1 controls the flow of cooling fluid through the **Thermal Chuck** radiator ring and the PUCK for cooling the chuck surface. The PUCK is purged of the cooling fluid when the temperature of the PUCK is 2° C greater than the COOL set point temperature.

4.5 LINEAR DC POWER SOURCE (DC-100)

The **Linear DC Power Source** is capable of delivering a linear 100 VDC, with less than 25 mV of ripple when delivering 10A. This is the DC power supplied to the THERMAL CHUCK assembly to heat the PUCK surface to the selected temperature designated by the **Heat Control Module**. Its output control signal is received via the interconnect cable from the **Heat Control Module**. The front panel meters allow the operator to observe the power being supplied to the **Thermal Chuck** assembly at any given time.

EXAMPLE:

Operating at approximately 350 °C, the operator will note that the supply is delivering between 60 to 70 volts DC and 5 to 6 amps DC to maintain the selected temperature. On the approach to the selected setting from ambient to 350 °C, you will notice that the DC volt will equal 100 and the amps will equal 8 to 9 1/2 amps depending upon the THERMAL CHUCK assembly.

Observing the actual PID control functions on the front panel meters allows the operator to see that the system is operating properly.

The **Linear DC Power Source** is a convertible power supply that can be switched from 120 VAC to 220 VAC operation by qualified service personnel. It has a large internal transformer with jumpers that need to be switched when converting. When a **Linear DC Power Source** is ordered, the required voltage setting must appear on the Sales Order in the form of either option V1 (120VAC) or V2 (220VAC) so that the jumpers can be switched at the factory for proper testing.



CAUTION: *Power Supply jumpers may be changed in the field. However, they must be changed by factory authorized personnel.*

SECTION 5.0

ZERO °C COOLING OPTION

5.1 INTRODUCTION

The **ZERO °C COOLING OPTION** is incorporated as a part of the **H-1000 THERMAL CHUCK SYSTEM®**.

A recirculating cooler or chiller is a device which controls the temperature of a process by heating or removing heat from a process by circulating a fluid. The circulated fluid flows from the cooler to the process and back in a closed loop.

The zero degree cooling option includes the required equipment for control of the fluid include a pump, reservoir, heat rejection method, and a temperature controller.

5.1.1 The Reservoir

The RESERVOIR is required for the following two (2) reasons:

1. Fluid Expansion and Contraction

When the temperature of fluid is changed, a change in volume occurs. As temperatures decrease the volume decreases, and vise-versa. The reservoir must be large enough to accommodate the expansion and contraction of the fluid.

2. System Initial Fill

The reservoir is initially filled prior to start up. If the process is not precharged, there must be sufficient fluid in the reservoir to fill the process which still having a sufficient volume to prevent pump cavitation.

5.1.2 Heat Transfer

A RECIRCULATING cooler is considered a forced convection heat transfer device. The mass flow of liquid flowing through the process heat exchanger allows temperature control by adding or removing heat as required. Heat transfer is affected by many different fluid characteristics which include:

DENSITY VISCOSITY FLOW RATE
SPECIFIC HEAT TEMPERATURE DIFFERENTIAL

To calculate heat removal, the temperature of the fluid entering the process and exiting the process must be measured. The mass flow rate of liquid and it's specific heat are required .

FORMULA

$$Q = M C_p dT$$

Q = Heat Removal (BTU/HR)

M = Mass Flow (LB/HR)

C_p = Specific Heat (BTU/LB/F)

dT = Temp Differential (F)

For water flowing at **2 gallons per minute** with an inlet **temperature of 72° F** and outlet **temperature of 80°** we can calculate the heat removal:

$$Q = (2 \text{ GPM} * 8 \text{ lb/gal} * 60 \text{ min/hr}) * 1 \text{ BTU/LB/F} * 8 \text{ F}$$

$$Q = 7680 \text{ BTU/HR} = 2250 \text{ Watts}$$

The VISCOSITY of the liquid is very important when deciding on what fluid to use for the application. At no time should the fluid viscosity be above **20 CENTISTOKES**. Viscosities higher than 20 centistokes will result in decreasing heat transfer.

5.2 SYSTEM DESCRIPTION

This system is designed to operate on a continuous basis with minimal interruption for maintenance and service. The system uses a single compressor to chill the cooling fluid.

RECIRCULATING coolers include a mechanically refrigerated heat exchanger, a fluid reservoir, a pump and a temperature controller as standard features.

The fluid flows from the reservoir through the pump and is pushed through the heat exchanger. The process equipment is attached to the outlet. The process outlet is attached to the inlet.

The system may be operated in either an open mode to allow air to escape that is used during the purge cycle.

5.2.1 Pump

The zero degree system uses a high pressure displacement pump.

High Pressure Pumps

HPP-2	Procon #1304 w/strainer
HPP-4	Procon #2507 w/o strainer

Type: Positive displacement, rotary-vane type pumps

Pump housing is brass, and internal metal parts are stainless steel or brass. Internal bearings, vanes, and liner are made from a special carbon graphite material which is selflubricating, heat-resistance, chemically and mechanically inert, and harder than many steels.

HPP-2

Body Material	Brass
Capacity	15 to 100 GPH
Pressure	25 PSI at 100 GPH 150 PSI at 95 GPH
Normal Speed	1725 RPM (60 Hz)
Max. Discharge	200 PSI
Rotation	CW (from nameplate view)

The chiller has external plumbing installed to provide a bypass for operation where the coolant is not flowing.

5.2.2 Safeties

To prevent damage to the devices under test, several safeties are built into the system.

Low Fluid Level Option

The low level sensor operates a contact closure which opens contacts to the heater, preventing heater operation.

Pump Failure (low pressure) Option

A pressure sensor is used as a PUMP FAILURE sensor. This safety function will not indicate if the system flow has stopped, it is intended to indicate when the pump has failed. The sensor is adjustable.

5.3 HEAT REMOVAL

The mechanical refrigeration system has a single stage refrigeration system. The refrigerant is expanded in the heat exchanger to provide cooling. A solenoid valve is used to control the flow of refrigerant to the heat exchanger for precise cooling control. The solenoid valve is normally **OPEN** to provide maximum cooling should the controller not be powered.

The heat exchanger is a stainless steel brazed plate unit. Air cooled mechanically refrigerated units depend on the ambient air to be drawn across the condensing fins. The cool air cools the hot gas inside the condenser which allows the gas to liquefy.

The air cooling process is critical. If the flow is blocked or the temperature of the air is too high, the gas is not cooled into a liquid and the result is loss of cooling in the heat exchanger.

Always be alert that the air flow can be blocked by dust in the condenser fins. Check the room temperature. Temperature above 72° F will reduce the specified heat removal.

BTU PER HR/WATTS	0	10	20
RS33	1706/500	2730/800	3750/1100

TABLE 5-1

The heat removal specifications for the unit are specified for an ambient temperature of 72 ° F which does not change. The fluid used for testing is **Glycol/water 60/40**.

5.4 SYSTEM SET-UP

The Recirculator is designed for operation in a normal environment. Air cooled systems require the room ambient temperature to be 72° F (25°) with up to 50% humidity. Water cooled systems require 30° C water and a pressure of 40 PSI to provide proper water flow.

ELECTRICAL REQUIREMENTS

RS33 120V, 60 Hz, 8A
AMBIENT: 72° F, 50% HUMIDITY

NOTE

All recirculators provide maximum cooling at temperatures below 72° F. Higher temperatures will degrade heat removal. **DO NOT** operate the systems in an ambient above 90° F.

SYSTEM PREPARATION FOR START-UP

- STEP 1. Check wall voltage. Does it match the system electrical requirements?
- STEP 2. Place all control switches in the **OFF** position.
- STEP 3. Attach SHORT CIRCUIT hoses to fluid I/O for testing. If water is cooled, attach water lines.
- STEP 4. Fill reservoir with fluid. Make sure the freezing point of the fluid is well below the systems maximum low temperature. **DO NOT** use water below 5° C.
- STEP 5. Check for leaks. Placing a piece of clean card board under the system will allow easy leak detection.
- STEP 6. Attach AC power. The AC power amber indicator will illuminate.
- STEP 7. Depress the **O/I** button (top most button) - controller will now turn **ON**.
- STEP 8. Adjust SET POINT to 0° .
- STEP 9. Turn REFRIGERATION **ON**.

5.5 MAINTENANCE

It is the operators responsibility to periodically check the system for proper operation. These operational checks must be performed on a weekly basis.

5.5.1 Refrigeration Condenser

For the mechanical refrigeration system to operate efficiently the condenser must be dust free. Over a period of time, dust will build up on the condenser which will decrease system performance. This dust must be vacuumed off. The condenser is located in the front of the system. The front of the system is removable for periodic maintenance.

NOTE

The rear and side panels must first be removed in order to clean the condenser.

Periodic Maintenance: 6 months (4000 hours)

5.5.2 HHP-2 Strainer

A strainer is provided as part of the pump head assembly on the HHP-2 series of pumps. The strainer should be periodically cleaned to prevent fluid flow reduction. The symptom of a clogged strainer is a noisy pump.

Periodic Maintenance: 6 months (4000 hours)

5.6 DO'S AND DON'TS

DO

- Provide adequate ventilation for refrigeration condenser
- Operate in an ambient of 72° F
- Use glycol/water below 8° C
- Perform periodic maintenance every 3-6 months
- Leave at least 6" on each side of the unit for proper air flow

DON'T

- Use water below 8° C
- Operate the high pressure pump without fluid or with fluid flow impeded
- Operate the equipment in an ambient above 90° F
- Block the condenser fins
- Operate at low voltage level
- Use flammable fluids for recirculation
- Push any side of the unit against the wall
- Operate with fluids with a pH of less than 5 or greater than 9
- Operate the system in a closet

5.7 FLUIDS IN RECIRCULATING SYSTEMS

Choosing the proper fluid for use in a recirculating system is the single most important decision to be made. Improper fluid can result in damage to the process and equipment.

5.7.1 Boiling Point

Fluids should be operated at temperatures no closer than 15 ° C to their boiling point. As the temperatures approach the boiling point, the pump will tend to cavitate (i.e. If a fluid boils at 100° C, it should not be used above 85° C

5.7.2 Glycol/Water

Glycol - Ethylene Glycol, Industrial Grade

When glycol and water are mixed they create a mixture which can be used at lower temperatures than either of the two individually. The ideal mixture for glycol/water is 60% glycol and 40% water.

Glycol is available in pure form or in anti-freeze form. Pure glycol is almost clear. Anti-freeze is green and includes additives which inhibit scaling, corrosion, and bacterial growth. The use of anti-freeze may cause the internal strainers to be cleaned more often. Pure glycol is recommended.

Freezing Points of Common Mixtures

The following are common fluid mixtures and their resulting freezing points. Note that the viscosity is NOT linear and therefore the freezing point and pumpability are NOT directly related. The intent of the charts is to provide the use with the optimum mixtures.

ETHYLENE GLYCOL/WATER

%VOLUMN	FREEZE Pt (F)
35	-4
40	-12.5
45	-22
50	-32.5 (*)

(*) Not Pumpable Below -22°F (-30° C)

TABLE 5-2

PROPYLENE GLYCOL/WATER

%VOLUMN	FREEZE Pt (F)
40	-5.5
45	-15
50	-25.5 (*)
55	-39.5
59	-57

(*) Not Pumpable Below -15°F (-25° C)

TABLE 5-3

5.8 TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	SOLUTIONS
UNIT WILL NOT START	1. Power is not connected properly.	1. Have electrician check power connections.
	2. Breaker at the wall is in the OFF position.	2. Turn breaker ON.
PUMP WILL NOT START	1. Power is not connected properly.	1. Have electrician check power connections.
	2. Breaker at the wall is in the OFF position.	2. Turn breaker ON.
	3. Impeller jammed.	3. Verify that motor is getting voltage and that the voltage is correct.

	4. Pump motor has overheated	4. The pump motor is provided with a thermal overload protection. If it overheats, the pump will shut down. This is usually a result of the pump being overworked. Check solutions under FLUID FLOW IS INADEQUATE.
PROBLEM	POSSIBLE CAUSE	SOLUTIONS
	5. Pump motor has burned out.	5. If all reasons listed above are not the cause and the pump has voltage to it, the pump motor is no good. Contact factory for new pump motor.
UNIT NOT COOLING PROPERLY	1. Temperature setting above fluid temperature	1. Adjust temperature setting to the proper setting
	2. Viscosity of fluid is too high for intended temperature range.	2. Change fluid.
	3. Ambient temperature too high.	3. To meet specifications, the room air temperature must be 72 ° F. The capacity of the cooling system and the maximum low temperature will degrade as the temperature increases.
	4. Plumbing incorrectly connected to process.	4. Check that LIQUID OUT port of system is connected to inlet of system to be cooled, and that LIQUID IN is connected to outlet of system to be cooled.
	5. Heat load is above unit's capacity.	5. Check to see that all lines have adequate insulation and that there are no local sources of heat which may be contributing to the load.

	6. Cooling water is inadequate or restricted.	6. A water cooled unit requires cooling water to be provided to the water cooled condenser. Check to see that cooling water supply is adequate.
	7. Cooling water is turned off.	7. Turn on cooling water. See UNIT CUTTING OUT ON HIGH PRESSURE.
PROBLEM	POSSIBLE CAUSE	SOLUTIONS
	8. Refrigerant leak.	8. Connect gauges and check static charge. If this confirms a leak, have the system leak checked, repair leak, and recharge system to proper level.
	9. Ball valve is closed.	9. Open ball valve.
	10. Fluid flow is inadequate	10. See FLUID FLOW IS INADEQUATE.
	11. Cooling valve is sticking.	11. Adjust temperature set point to cycle the cool indicator ON/OFF. This should result in a "clicking" sound from inside the machine.
TEMPERATURE CONTROLLER WILL NOT CONTROL TEMPERATURE	1. Open sensor	1. Measure resistance of sensor. It should be approximately 100 ohms. If it is not, a new sensor is needed. Contact Service Dept. for new sensor.
	2. Connection on controller has come loose.	2. Check all connections on controller inside the unit. If any are loose or disconnected, reconnect them.

	3. Low voltage to solenoid valves.	3. The controller is operating properly but because of inadequate voltage to solenoid valve, the valves are not opening and closing as needed. Correct voltage supplied to the unit.
	4. Defective solenoid valve.	4. The controller operating properly, but the solenoid valve is not responding because of a defect.
PROBLEM	POSSIBLE CAUSE	SOLUTIONS
FLUID FLOW IS INADEQUATE	1. Viscosity of fluid is too high for intended temperature range	1. Change fluid to a fluid with lower viscosity.
	2. Pump screen blocked, if using a high pressure pump such as HPP2 or HPP 4.	2. The inlet to the pump has a screen filter which is accessed by removing the insulation from the pump and removing the large nut on the pump housing.
	3. Ball valve is closed.	3. Open ball valve.
	4. Plumbing lines have become restricted or broken.	4. Check plumbing lines and repair as necessary.
	5. Restrictions in the system will not allow needed flow with supplied pump.	5. Use larger line sizes. Replace pump with pump capable of supplying needed flow with the given plumbing restrictions. Check with factory for warranty implications.
	6. Impeller or pump has been damaged.	6. Remove pump and check impeller, contact factory for replace pump or impeller. Determine cause of damage and correct cause to prevent future damage.

	7. Pump motor has overheated.	7. The pump motor is provided with a thermal overload protection. If it overheats, the pump will shut down and it will restart when the motor has cooled down. This is usually a result of the pump being overworked. Check the above items to see if they are causing the motor to overheat.
	8. Pump motor has burned out.	8. Contact service department for new pump motor.
PROBLEM	POSSIBLE CAUSE	SOLUTIONS
REFRIGERATION WILL NOT START	1. Pump switch is not ON.	1. Turn pump ON.
	2. Low/High Pressure (Ranco) Cut-out contacts are OPEN.	2. Press reset button on RANCO. If unit does not start, short contacts. If this does not start the unit, then this device is not the cause. If it does start, check refrigerant stats.
	3. Voltage is inadequate.	3. The compressor must have adequate voltage to start. Check voltage when power is applied to the system. If voltage is not within $\pm 5\%$ of the system rated voltage, contact the electrical department to have the voltage corrected.

UNIT CUTTING OUT ON HIGH PRESSURE	1. Cooling water blocked.	1. Remove obstruction or restriction.
	2. Ambient too warm.	2. The unit is designed for operation in an ambient environment of 72 ° F. Temperatures over 80° F may cause the compressor to overheat.
	3. Fan not working.	3. Check the fan for rotation. If the fan is not rotating check: • AC supply to fan • For blockage • Excessive dirt/dust
PROBLEM	POSSIBLE CAUSE	SOLUTIONS
	4. Condenser blocked.	4. The finned condenser requires adequate air flow to provide cooling. Make sure that the finned surface is 6" away from the wall and not clogged with dust.
	5. High pressure cut-out has been moved, and it is adjusted too low.	5. Apply refrigeration gauges, and check where the system is cutting out. Compare this to the settings listed in the QC sheets. Adjust to proper setting.
UNIT IS CUTTING OUT ON LOW PRESSURE	1. Low pressure cut-out has been moved, and is adjusted too high.	1. Remove filter screen by cutting back insulation and removing large nut on pump housing
PUMP MAKING LOUD NOISE	1. Blocked filter screen, if using HPP2 or HPP4.	1. Remove filter screen by cutting back insulation and removing large nut on pump housing.

	2. Fluid freezing or icing.	2. Make sure that there is no ice in the fluid. Straight water should not be used below 5 ° C. For lower temperature operation, mix with glycol.
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SECTION 6.0 MAINTENANCE AND TROUBLE SHOOTING

6.0 INTRODUCTION

This maintenance section is broken into two separate sections which are BASIC SYSTEM MAINTENANCE REQUIREMENTS and TROUBLE SHOOTING.

The first section will be the BASIC SYSTEM MAINTENANCE REQUIREMENTS which will be comprised of visual checks for good connections and general condition. Each of the topics in this section will have a recommended time period for the event to occur.

The second section will be the TROUBLE SHOOTING section which consist of a trouble shooting chart listing symptoms, cure and reference documents.

Appendix A (TEST PROCEDURES AND CHECKOUT SHEETS) and Appendix B (BILLS OF MATERIALS and ASSEMBLY DRAWINGS) are designed to work in conjunction with this maintenance section.

6.1 BASIC SYSTEM MAINTENANCE

6.1.1 Heat Controllers (Recommended Every Six Months)

A. AC and DC HEAT CONTROLLER OVERTEMP AND ISOLATION RELAYS CHECK

1. Turn **ON** the controller and ensure that it is in the **STOP** mode. Disconnect the **T/C** cable from either the rear of the **TEMPERATURE CONTROLLER** or the **PROBE STATION**.
2. The front panel temperature displays should show **4 DASHES**. The red **LIMIT** LED (on the rear panel of the controller) should light within 25 seconds. After the **LIMIT** LED has lit, reconnect the **T/C** cable.
3. Once the temperature displays resume normal indication, set the **HEAT SETPOINT** to any temperature that is 10 degrees higher than the indicated **THERMAL CHUCK** temperature and place controller in **HEAT** mode. The **CHUCK** temperature should not increase (**ISOLATION RELAYS** need to be replaced if controller heats in this mode). Place **HEAT CONTROLLER** in **HEAT** mode. The **THERMAL CHUCK** should now begin heating.

B. SP2 SETPOINT CHICK AC CONTROLLERS ONLY (SP2 =3)

To check the **SP2** setting, depress and release the hidden button located between the **DSPY MODE** and **UP ARROW** buttons. The red **SET TEMP** display should read **SP2** and the green display should read **3.0**. The **UP** and **DOWN ARROW** buttons are used to adjust this value when necessary.

6.1.2 Cool Modules (Recommended Every Six Months)

A. AMBIENT COOL OPTION CONTROL MODULE

1. SP2 SETPOINT CHECK (SP2=0)

To check the **SP2** setting, depress and release the hidden button located between the **DSPY MODE** and **UP ARROW** buttons. The red **SET TEMP** display should read **SP2** and the green display should read **0**. The **UP** and **DOWN ARROW** buttons are used to adjust this value when necessary

2. PURGE TIMER CHICK (60 SECONDS)

Turn the controller **ON** and ensure that it is in the **STOP** mode. Check that an **AIR PURGE** is initiated (**PURGE** light lit and air blowing through cooling tubes of the **THERMAL CHUCK**). This could last from 60 to 90 seconds and then go **IDLE**. If **NO PURGE** occurs, initiate **MANUAL PURGE** using the **PURGE SWITCH** (this verifies control cables are air are connected to the **SRV** module or **HEAT EXCHANGER**). If **PURGE** occurs manually but not automatically, then interval in **COOL** module needs to be reset or replaced. The **INTERVAL TIMER** is mounted inside the **COOL** module. The timer has a scaled face for adjusting the time. The timer is typically set to 60 seconds but should be adjusted to ensure adequate time to remove water or coolant from the **THERMAL CHUCKS** cooling tubes.

6.1.3 Service Modules (Recommended Every Six Months)

- A. SRV1** modules regulator settings and flow checks - refer to A1010812 Test and Check Out Sheet.
- B. HEAT EXCHANGERS** regulator settings and flow check, refer to A1011113 Test and Check Out Sheet.

6.1.4 Small Chillers

A. Clean **CONDENSER** weekly (Reference Section 5.5.1)

B. Clean **STRAINERS** every six months (Reference Section 5.5.2).

6.1.5 Thermal Chucks. (Recommended Every Three Months)

Visual check for GOOD connections and general condition.

6.2 TROUBLE SHOOTING

The following table is a compiled list of probable symptoms, cures and reference documents to help in repairing malfunctions that may occur during a chiller systems operation.

TROUBLE SHOOTING TABLE

HEAT SYMPTOMS	CURE	REF. DOC.
SYSTEM DOES NOT HEAT	1. EMO switch is OFF position. Check switch.	Test sheets: A1011416 A1011024
	2. Open Chuck connections from controller to chuck. Check light on controller rear panel Check Heater power cable attached. Check all connections	Assembly prints: A1010509-A AC controllers; A1009795 for DC controllers A1010968, A1010967 A1010594, A1010825
	3. Open heater in chuck assembly. Check heater resistance (Pins 1 & 4 heater power cable)	CHK880-6C, CHK8800-8T, A1011467
	4. Isolation relays open. Check Overtemperature controller operation. Isolation relays or Overtemperature controller failed. Replace failed components.	

SYSTEM HEATS SLOWLY	1. Improper voltage power to chuck; 100 to 130 Volts required for standard chucks and 210 to 250 volts required for "V2" chuck assemblies. Check heater power and chuck assembly rating. 2. PIDs set incorrectly. Check PID settings. 3. Controller configured for "RAMP" operations is with slow ramp rate. "RAMP" operations is an advanced usage. Consult factory.	Test sheets: A1011416, A1011024 Assembly prints: CHK8800-6C CHK8800-8T A1011467
SYSTEM OVERSHOOTS WHEN HEATING	Standard PIDs can cause small Overshoots when heating to temperatures less than 125°C. 1. PIDs set incorrectly. Check settings. 2. Improper voltage power to chuck; 100 to 130 Volts required for standard chuck and 210 to 250 volts required for "V2" chuck assemblies. Excessive voltage causes Overshooting. Check heater power and Chuck assembly rating 3. Controller configured for "RAMP" operations. "RAMP" operations is an advanced usage. Consult factory	Test sheets: A1011416, A1011024 Assembly prints: CHK8800-6C CHK8800-8T, A1011467
ERRATIC TEMPERATURE DISPLAY ON HEAT CONTROLLER	1. Bad RTD connections. Check connector and T/C cable assemblies. Check thermal chuck assembly connections	Assembly prints: A1010509-A/B A1009795, A1010568, A1010895, A1010968, A1010967, A1010594, A1010825, CHK8800-6C, CHK8800-8T, A1011467

ERRATIC TEMPERATURE CONTROL IN HEAT MODE	1. Bad RTD connection. Check connector and T/C cable assemblies. Check thermal chuck assembly connections. 2. Bad Heater power connections. Check heater power cable connections from controller to chuck. 3. PIDs set incorrectly. Check PID settings. 4. Controller configured for "RAMP" operations. "RAMP" operations is an advanced usage. Consult factory 5. Define erratic behavior. Consult factory.	Test sheets: A1011416 Assembly prints: A1010509-A/B, A1009795, A1010568, A1010895, A1010968, A1010967, A1010594, A1010825, CHK8800-6C, CHK8800-8T, A1011467, A1009857
SYSTEM IS IN HEAT MODE WHEN THE POWER IS TURNED ON	1. Voltage spike caused Power ON Reset PCB assembly malfunction. Cycle Power ON controller. If problem persists, replace A1009794	Assembly prints: A1010509-A AC controllers: A1009795 for DC controllers: A1010967
SYSTEM IS IN HEAT MODE AND COOL MODE SIMULTANEOUSLY	1. Voltage spike caused Power ON Reset PCB assembly malfunction. Cycle Power ON controller. If problem persists, replace A1009794.	Assembly prints: A1010509-A, A1009795, A1010967
DASHED TEMPERATURE DISPLAY ON HEAT CONTROLLER	1. Open RTD connections. Check connector and T/C cable assemblies from controller to probe station. 2. Chuck not connected. Check Chuck connections.	Assembly prints: A1010509-A/B, A1009795, A1010568, A1010895, A1010968, A1010967, A1010594, A1010825, CHKK8800-6C, CHK8800-8T, A1011467
NO TEMPERATURE DISPLAY ON HEAT CONTROLLER	1. No power. Check power cable plugged in. Check circuit breakers on controller rear panel	Visual - N/A

COOLING SYMPTOMS	CURE	REF. DOC.
SYSTEM DOES NOT COOL	1. System not connected properly. Check electrical connections from COOL MODULE to SRV or HEAT EXCHANGER. Check all plumbing connections in system. Coolant source disabled. Verify coolant source active. 2. Failed coolant valve in SRV or HEAT EXCHANGER. Check and replace if necessary. 3. Failed coolant regulator in SRV. Check and reset if necessary. 4. Cooling module controller failed. Check operation.	User Manual for system interconnect. Test sheets: A1010813, A1011213, A1010812, A1011113 Assembly prints: A1010600, A1010760, A1010601, A1010775-A
SYSTEM COOLS SLOWLY	1. High coolant temperature. Check coolant temperature. 2. Low flow. Check coolant source to SRV1 module. Check flow rate to chuck cooling tubes. Check flow rate through chuck cooling tubes. 3. Controller configured for "RAMP" operations. "RAMP" operation is an advanced usage. Consult factory.	User Manual for systems interconnect. Test sheets: A1010812, A1011113 Assembly prints: A1010601, A1010775-A
ERRATIC TEMPERATURE DISPLAY ON COOL MODULE	1. Bad RTD connections. Check connector and T/C cable assemblies. Check thermal chuck assembly connections.	Assembly prints: A1010509-A/B, A1009795, A1010568, A1010895, A1010968, A1010967, A1010600, A1010760, A1010594, A1010825, CHK8800-6C, CHK8800-8T, A1011467

ERRATIC TEMPERATURE CONTROL IN COOL MODE	1. Bad RTD connections. Check connector and T/C cable assemblies. Check thermal chuck assembly connections. 2. PIDs set incorrectly. Check PID settings. 3. Controller configured for "RAMP" operations "RAMP" operations is an advanced usage. Consult factory. 4. Define erratic behavior. Consult factory.	Test sheets: A1010812, A101113 Assembly prints: A1010509-A/B, A1009795, A1010568, A1010895, A1010968, A1010967, A1010600, A1010760, A1010594, A1010825, CHK8800-6C, CHK8800-8T, A1011467
SYSTEM IS IN COOL WHEN THE POWER IS TURNED ON	1. Voltage spike causes Power ON Reset PCB assembly malfunction. Cycle power on controller. If problem persists replace A1009794	Assembly prints: A1010509-A AC controllers: A1009795 for DC controllers, A1010967
SYSTEM IS IN HEAT MODE AND COOL MODE SIMULTANEOUSLY	1. Voltage spike causes Power ON Reset PCB assembly malfunction. Cycle power on controller. If problem persists replace A1009794	Assembly prints: A1010509-A, A1009795, A1010967
NO TEMPERATURE DISPLAY ON COOL MODULE	1. No Power Check interface cable connected between COOLING MODULE and HEAT controller	User Manual for system interconnect.

PURGE SYMPTOMS	CURE	REF. DOC.
SYSTEM DOES NOT PURGE	1. Air not connected. Check air supply to system is connected. 2. Interval timer failed. Initiate manual purge. Check that manual purge works. If manual purge works, replace Interval timer. 3. Air valve in SRV or Heat exchanger failed. Initiate manual purge to check valve operation. 4. Air regulator in SRV or Heat exchanger needs to be reset. Initiate manual purge to adjust regulator.	User Manual for system interconnect. Test sheets: A1010812, A1011113, A1010813, A1011213 Assembly prints: A1010600, A1010760
PURGE TIME VERY SHORT	1. Internal timer needs to be reset	Test sheets: A1010813, A1011213 Assembly prints: A1010600, A1010760
PURGE TIME VERY LONG	1. Interval timer needs to be reset	Test sheets: A1010813, A1011213 Assembly prints: A1010600, A1010760
PURGE INDICATOR DOES NOT ILLUMINATE	1. Lamp out. Replace lamp.	Assembly prints: A1010600, A1010760
PURGE INDICATOR DOES NOT TURN OFF	1. PURGE switch latched in "ON" position. Press and release PURGE switch. 2. Interval Timer failed ON. Replace timer.	Assembly prints: A1010600, A1010760

INDICATOR SYMPTOMS	CURE	REF. DOC.
RESET INDICATOR ON REAR OF HEAT CONTROLLER IS ON	1. Press and release RESET button or cycle Controller power off and then back on	User Manual
RESET INDICATOR ON REAR OF HEAT CONTROLLER WILL TURN OFF	1. Open thermocouple in Chuck. Check all T/C connections. Measure continuity of thermocouple in thermal chuck assembly. Wire in spare thermocouple if necessary 2. Overtemperature controller failed. Check operation and replace if necessary.	Test sheets: A1011416, A1011024 Assembly prints: A1010509, A1009795, A1010968, A1010967, A1010594, A1010825, A1010467, CHK8800-6C, CHK8800-8T
ZERO DEGREE CHILLER SYMPTOMS	CURE	REF. DOC.
LA INDICATOR ON ZERO DEGREE CHILLER IS ON	1. low Alarm: If the process temperature falls below this value, the LA alarm prompt is added to the process display. System menus were altered. Check menus. 2. Temp sensor failed	FTS RS33A001 manual
HA INDICATOR ON ZERO DEGREE CHILLER IS ON	1. High Alarm: The temperature which, it exceeded by the process temperature, causes application of the HA alarm message when the system is running. This operation may be normal. The temperature of the reservoir may exceed the HA setpoint when cooling the chuck from elevated temperatures. Pres the UP arrow on the chiller to reset the HA indicator. Check System menus. Reset if necessary. 2. Temp sensor failed.	FTS RS33A001 manual

ZERO DEGREE CHILLER RESERVOIR OVERFLOWS DURING PURGE	1. Reservoir is overfilled or purge pressure is too great. Check fluid level. Adjust air regulator in SRV module as necessary to stop overflow.	Assembly print: A1010601
CHUCK SYMPTOMS	CURE	REF. DOC.
RADIATOR IS HOT WHEN CHUCK IS HOT	1. No or low radiator cooling flow. Check that there is flow to radiator. Check that there is flow through the radiator.	User Manual. The radiator should always be connected to a cooling system regardless of whether a cooling option is purchased.
RADIATOR HAS CONDENSATION OR SWEATS	1. Temperature of the radiator is lower than dew point of air in surrounding environment. Check dew point of air.	
CHUCK HAS CONDENSATION OR FROST	1. Temperature of the chuck is lower than dew point of air in surrounding environment. Check dew point of air	

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APPENDIX A

HEAT/COOL MODULE CONTROL COMMANDS

APPENDIX A

HEAT\COOL MODULES CONTROL COMMANDS

Commands for controlling the new Micromanipulator Heat and Cool Modules

This information is intended explain the control specific commands and their implementation. for the new Micromanipulator Heat and Cool control Modules. Two different forms of serial communications are available.

The Micromanipulator Heat and Cool control modules with computer control come standard with RS-422. RS-485 is available on special request. These modules are delivered set up for RS-422 communications with the Heat modules set at address N0. 1 and optional Cool Modules set at address No. 2.

The following defaults are in effect.

Baud Rate	9600 bps
Data Rules	7 data bits and odd parity
Protocol	ANSI X3.28 2.2-a.3
Address	Heat module = 1 Cool module = 2
Interface	RS-422

As soon as you link the devices, you'll be able to talk to the controllers using ASCII characters. The controller will respond to either upper or lower case ASCII characters from your computer as long as the commands or queries are correctly transmitted. Remember, every message requires both beginning and ending characters.

ASCII CONTROL CHARACTER DEFINITIONS:

- ENQ** Enquiry (Inquiry): Request for a data link.
ACK Acknowledge: Affirmative Response from the receiver.
NAK Negative Acknowledge: Negative response from the receiver.
STX Start of Text: Precedes any message from the sender.
ETX End of Text: Follows any message from the sender.
EOT End of Transmission: Tells the other device that it is its turn to send a message.
DLE Data Link Escape: Disconnect signal from the master to devices on the network.

NOTE

Reference the end of this section for
ASCII control characters

ASCII COMMAND LIST:

- ? Returns the value of a specific prompt from the controller.
- = Sets a specific prompt in the controller to a specific value.

DATA RULES:

- ♦ Data will include the characters 0 through 9; a decimal point if needed; or a positive or negative sign.
- ♦ Data can include up to seven characters. A "+" or "-" sign, if used, must be first.
- ♦ Data can use leading zeroes, up to the seven-character limit.
- ♦ The data.1 portion of message can be up to four total characters.

MESSAGE SYNTAX:

Messages from your computer to a controller must take this general form:

Command <space> data.1 <space> data.2 <space> data.3.....data.N

"Command" is a character string. The brackets "<" and ">" enclose a non-literal description. The space character , <space> or <sp>, is simply a delimiter, an ASCII space character (hex 20). "Data fields" are prompts and values specific to the command. The number of data fields depends on the particular command. The first argument or parameter is abbreviated, "data.1" the next is "data.2" and so on.

THE MICROMANIPULATOR CONTROLLERS COMMAND SUMMARY

*Name data.1	Description	Read (?) and/or Write (=) Syntax	Range data.2
C1	Chuck Temperature	? <sp> C1 <cr>	Temperature in degrees selected, default is degrees C. Temperature must fall in designated range of selected Controller and Chuck system.
SP1	Controller Setpoint Temperature	? <sp> SP1 <cr> = <sp> SP1 <sp> data.2 <cr>	Temperature in degrees selected, default is degrees C. Temperature must fall in designated range of selected Controller and Chuck system.

EI1	Controller Actuation	? <sp> EI1 <cr> = <sp> EI1 <sp> data.2 <cr>	1 = Computer Execute Controller operation to maintain SP1 (For Addr. 1 = Heat command For Addr. 2 = Cool command) 5 = Stop or idle command. On "AC" powered chucks. *1 EI1 must be reset to EI1 = 5 for correct Controller Front Panel (manual operation) when ever finishing any computer controlled operations. Default = 5
EI1S	Controller Status for Front Panel Operation. NOTE: These Controllers can be operated from both the front panel controls and or the computer when EI1 = 3	? <sp> EI1S <cr>	0 = Front Panel Controller Function (Heat or Cool) Actuated. 1 = Front Panel Controller Function switch is off stopped
DEV	Deviation: Difference between Setpoint and Chuck Temperature	? <sp> DEV <cr>	Temperature in degrees selected, default is degrees C.
OT2	Isolation relay control for DC power chucks	= <sp> OT2 <sp> data 2 <cr>	3 = Relays energized 4 = Relays de-energized Default = 3 Not used on AC powered chucks
CF	Temperature Format: Degrees C. / F.	? <sp> CF <cr> = <sp> CF <sp> data.2 <cr>	0 = Degrees F 1 = Degrees C. Default = 1
LOC *2	Setpoint Controller Front panel lockout	? <sp> LOC <cr> = <sp> LOC <sp> data.2 <cr>	0 = No lockout 3 = Keyboard locked out Default = 0 *3

ER	Error, Analog Input (multiple errors possible)	? <sp> ER <cr>	0 = No Error 1 = Input A-D overflow 2 = Input Overrange 3 = Input Underange 4 = Input A-D Underflow 9 = Ambient Error
ER2	Error, Communications	? <sp> ER2 <cr>	0 = No Error 1 = Transmit buffer error 2 = Receive buffer error 3 = Framing error 4 = Overrun error 5 = Parity error 6 = Talking out of turn 7 = Invalid reply error 8 = Noise error 20 = Command not found 21 = Prompt not found 22 = Incomplete command line 23 = Invalid character 24 = Number of characters overflow 25 = Input out of limit 26 = Read only command 27 = Write allowed only 28 = Prompt not active 30 = Request to RUN invalid 31 = Request to HOLD invalid 32 = Command invalid in RUN Mode 33 = Command invalid in HOLD Mode 34 = Output 3 is not an event 35 = Output 4 is not an event 39 = Asterisk not allowed 39 = Infinite loop error
ERR	Error, Latching Enable	? <sp> ERR <cr> = <sp> ERR <sp> data.2 <cr>	0 = errors latching 1 = errors nonlatching Default = 1 Recommend that system always be operated in this mode.

Remember: Heat modules set at address No. 1 and Cool Modules set at address No. 2. The commands are the same for either controller.

***1** EI1 must be reset to EI1 = 5 for correct Controller Front Panel (manual) operation when ever finishing any computer controlled operations . This can be thought of as "Obey front panel actuators control command".

***2** LOC Must be set to 0 for correct Controller Front Panel (manual) operation.

RS-422 uses ANSI X3.28 Protocol. ANSI X3.28 Protocol provides high quality communications by requiring a response to every message. With a multiple-device network, this protocol prevents confusion among separate devices. Furthermore, if noise occurs somewhere in the system, no prompt will change because noise cannot comply with this protocol.

ANSI X3.28 PROTOCOL RULES:

- 1. Every remote device must have a unique address.**
- 2. Only the master can initiate a communication session, by addressing a specific remote device.**
- 3. Every message requires both beginning and ending characters. Every message must be framed with an <STX> (start of transmission) character and an <ETX> (end of transmission) character.**
- 4. The master must wait for the remote device to respond to every message within a reasonable period. If no response occurs, retry the connection or pursue error recovery.**

Here are some example communications links:
This first example is establishing communications link

Source	String	Conversation
Master	1 <ENQ>	Attempt to link with Heat controller are you there?
Heat controller	1 <ACK>	Heat controller "I'm here"
Master	<DLE> <ENQ>	End data link
Heat controller		No response required or provided.

"=" Example

The controller is idle and the chuck is sitting at 30 degrees C.

Master	1 <ENQ>	Attempt to link with Heat controller are you there?
Heat controller	1 <ACK>	Heat controller "I'm here"
Master	<STX> = <sp> SP1 <sp> 200 <ETX>	Set the heat control temperature to 200

Heat controller	<ACK	This response occurs after the command change has occurred in this case the set point changed to 200.
Master	<DLE> <ENQ>	End data link
Master	2 <ENQ>	Attempt to link with Cool controller are you there?
Cool controller	2 <ACK>	Cool controller "I'm here"
Master	<STX> = <sp> SP1 <sp> 30 <ETX>	Set the cool control temperature to 30
Cool controller	<ACK	This response occurs after the command change has occurred in this case the set point changed to 30
Master	<DLE> <ENQ>	End data link
In this example you have set the high temperature setpoint to 200 degrees and the cool setpoint to 30 degrees, and ended the data links.		

"?" Command Example:

The controller is idle and the chuck is sitting at 30 degrees C.

Master	1 <ENQ>	Attempt to link with Heat controller are you there?
Heat controller	1 <ACK>	Heat controller "I'm here"
Master	<STX> ? <sp> C1 <ETX>	What temperature are you reading
Heat Controller	<ACK> or <NAK>	<ACK> will be returned once the device has the response ready. DO NOT send <EOT> until this character has been received. <NAK> means the message was not understood and the message must be resent.
Master	<EOT>	The host gives the device permission to respond.
Heat Controller	<STX> 30 <ETX>	Its 30 °C. the device sends back the temperature it is reading. Do not send a response until the <ETX> has been received.
Master	<ACK> or <NAK>	<ACK> means host received message correctly. <NAK> means host did not understand the response. The remote will resend the response.
Heat Controller	<EOT>	Returns control back to Host.
Master	<STX> ? <sp> SP1 <ETX>	What is your control temperature setpoint?
Heat Controller	<ACK>	I understand the question
Master	<EOT>	that's all go ahead and tell me.
Heat Controller	<STX> 200 <ETX>	The setpoint is 200 degrees.

Master	<ACK>	<ACK> means host received message correctly.
Heat Controller	<EOT>	Returns control back to Host.
Master	<DLE> <ENQ>	End data link This step is not necessary unless you wish to truly end the data link.
Master	2 <ENQ>	Cool controller are you there?
Cool controller	2 <ACK>	I'm here
Master	<STX> ? <sp> C1 <ETX>	What temperature are you reading
Cool Controller	<ACK> or <NAK>	<ACK> will be returned once the device has the response ready. DO NOT send <EOT> until this character has been received. <NAK> means the message was not understood and the message must be resent.
Master	<EOT>	The host gives the device permission to respond.
Cool Controller	<STX> 30 <ETX>	Its 30 °C. the device sends back the temperature it is reading. Do not send a response until the <ETX> has been received.
Master	<ACK> or <NAK>	<ACK> means host received message correctly. <NAK> means host did not understand the response. The remote will resend the response.
Cool Controller	<EOT>	Returns control back to Host.
Master	<STX> ? <sp> SP1 <ETX>	What is your control temperature setpoint?
Cool Controller	<ACK>	I understand the question
Master	<EOT>	that's all go ahead and tell me.
Cool Controller	<STX> 30 <ETX>	The setpoint is 30 degrees.
Master	<ACK>	<ACK> means host received message correctly.
Cool Controller	<EOT>	Returns control back to Host.
In this example you have asked what the temperature of the chuck is and confirmed the new setpoints for the control modules. The major difference is you are required to "end transmission" after inquiring in order for the controllers to respond.		

Now lets heat the chuck to 300 °C then cool to 25 °C and end the computer link.

Master	1 <ENQ>	Attempt to link with Heat controller are you there?
Heat controller	1 <ACK>	Heat controller "I'm here"

Master	<STX> = <sp> SP1 <sp> 300 <ETX>	Set the heat control temperature to 300
Heat controller	<ACK>	This response occurs after the command change has occurred in this case the set point changed to 300.
Master	<STX> = <sp> EI1 <sp> 1 <ETX>	Execute "heat" command
Heat controller	<ACK>	This response occurs after the command change has occurred in this case the controller initiates heating of the chuck.
Master	<STX> ? <sp> C1 <ETX>	What temperature is the chuck.
Heat Controller	<ACK> or <NAK>	<ACK> will be returned once the device has the response ready. DO NOT send <EOT> until this character has been received. <NAK> means the message was not understood and the message must be resent.
Master	<EOT>	The host gives the device permission to respond.
Heat Controller	<STX> 125 <ETX>	Its 125 °C. (the chuck is still heating up to its setpoint) the device sends back the temperature it is reading. Do not send a response until the <ETX> has been received.
Master	<ACK> or <NAK>	<ACK> means host received message correctly. <NAK> means host did not understand the response. The remote will resend the response.
Heat Controller	<EOT>	Returns control back to Host.
This series of inquiries can be initiated repeatedly until the controller responds back with 300 °C.		
Master	<STX> ? <sp> C1 <ETX>	What temperature are you reading
Heat Controller	<ACK>	<ACK> will be returned once the device has the response ready.
Master	<EOT>	The host gives the device permission to respond.
Heat Controller	<STX> 300 <ETX>	Its 300 °C. the device sends back the temperature it is reading. Do not send a response until the <ETX> has been received.
Master	<ACK>	<ACK> means host received message correctly.
Heat Controller	<EOT>	Returns control back to Host.
Master	<STX> = <sp> EI1 <sp> 5 <ETX>	Stop "heat" command

Heat Controller	<ACK>	This response occurs after the command change has occurred in this case the controller enters into an idle mode with the isolation relays deenergized).
Master	2 <ENQ>	Attempt to link with Cool controller are you there?
Cool Controller	2 <ACK>	I'm here
Master	<STX> = <sp> SP1 <sp> 25 <ETX>	Change cooling setpoint to 25 °C.
Cool Controller	<ACK	This response occurs after the command change has occurred in this case the controller setpoint changes to 25.
Master	<STX> = <sp> EI1 <sp> 1 <ETX>	Execute "cool" command
Cool Controller	<ACK	This response occurs after the command change has occurred in this case the controller initiates cooling of the chuck.
Master	<STX> ? <sp> C1 <ETX>	What temperature is the chuck.
Cool Controller	<ACK>	<ACK> will be returned once the device has the response ready. DO NOT send <EOT> until this character has been received.
Master	<EOT>	The host gives the device permission to respond.
Cool Controller	<STX> 225 <ETX>	Its 225 °C. (the chuck is still cooling down to its setpoint) the device sends back the temperature it is reading. Do not send a response until the <ETX> has been received.
Master	<ACK>	<ACK> means host received message correctly.
Cool Controller	<EOT>	Returns control back to Host.
This series of inquiries can be initiated repeatedly until the controller responds back with 25 °C.		
Master	<STX> ? <sp> C1 <ETX>	What temperature is the chuck.
Cool Controller	<ACK>	<ACK> will be returned once the device has the response ready.
Master	<EOT>	The host gives the device permission to respond.
Cool Controller	<STX> 25 <ETX>	Its 25 °C. (the chuck has cooled down to its setpoint) the device sends back the temperature it is reading. Do not send a response until the <ETX> has been received.
Master	<ACK>	<ACK> means host received message correctly.

Cool Controller	<EOT>	Returns control back to Host.
Master	<STX> = <sp> E11 <sp> 5 <ETX>	Cool control stop.
Cool Controller	<ACK>	OK
Master	<DLE> <ENQ>	End data link
Master	1 <ENQ>	Attempt to link with Heat controller are you there?
Heat Controller	1 <ACK>	Heat controller "I'm here"
Master	<DLE> <ENQ>	End data link
The controllers are sitting idle or stopped.		

For Maximum Communications Speed:

1. Do not use a typical delay to wait before looking for a response.
2. Scan for returned characters until the correct response is received.
3. Use a time-out to end a session if a correct response is not received in three seconds.
4. Protocols are not flexible. Outside of the <STX> <ETX> framing only the defined protocol characters are allowed. Some Programming languages add <cr> to the end of transmissions. This must be disabled.
5. End the communications link and re-establish it with <DLE> and <ENQ> only when changing to a new device at a different address. The master can communicate repeatedly with a specific device once the initial data link is established.

ASCII CONTROL CHARACTERS (PARTIAL SET)

ASCII Char.	Ctrl Key Equiv	Definition	Dec Equiv	Hex Equiv
ENQ	Ctrl E	Enquiry	5	05
ACK	Ctrl F	Acknowledge	6	06
NAK	Ctrl H	Neg. Acknowledge	21	15
STX	Ctrl B	Start of Text	2	02
ETX	Ctrl C	End of Text	3	03
EOT	Ctrl D	End of Transmission	4	04
DLE	Ctrl P	Data Link Escape	16	10
CR	Ctrl M	Carriage Return	13	0D
DC1	Ctrl Q	XON	17	11
DC3	Ctrl S	XOFF	19	13

IEEE INTERFACE

The **H1000** HEAT and COOL control modules each have a built-in serial RS-422 interface. The RS-422 interface uses five wires, a differential voltage to transmit binary data. One master controller can handle up to ten remote devices on a network up to 4,000 feet long.

RS-422 interfaces, however, are not common in laboratory and test environments. IEEE-488 (commonly referred to as GPIB) communication interfaces are much more common and have become a virtual standard interface on test and measurement equipment.

The **H1000-IEEE** product was developed to provide a IEEE-422 port as the slave port. In GMode, the converter uses two IEEE-488 addresses. Address 5 is the address for the converter *itself*. Address 5 is used to communicate with the converter to get STATUS and to CONFIGURE the RS-422 port. The commands interpreted by the converter at address 5 are described in detail with the documentation supplied with the **H1000-IEEE**. Address 6 is used for data to be passed through to the RS-422 port.

In order to use the **H1000-IEEE** interface, the converter module must be sent configuration data to address 5. The following commands are used to configure the RS-422 port:

spset 9600,o,7,1
spset

The **spset** command is used to both set and get the RS-422 port configuration. The first command sets the RS-422 baud rate to **9600**, with **o** (odd) parity, **7** data bits and **1** stop bit. All commands to address 5 need to be followed by a CR (decimal 13) character. The second **spset** command is sent:

9600 o 7 1

The correct response from the **H1000-IEEE** indicates that it is now configured to route commands sent to address 6 from the IEEE-488 port through to the two RS-422 ports. Refer to the **H1000** users manual for the exact syntax or commands to be sent to the **H1000** HEAT and COOL controllers via this communication path.

The data exchange between the RS-422 devices and the IEEE-488 port is not always a very smooth and timely one. The **stat n** command can be very useful to determine the number of bytes available at the IEEE-488 port and therefore check that expected data is in fact present at the IEEE-488 port. The **stat n** command is sent to address 5 and is documented in the National Instrument's GPIB-232//485CT-A User Manual.

The following sample program illustrates the use of the above functions in a typical application, as well as providing examples of basic read and write operations to and from **H1000** HEAT controller.

/*Sampl.c - Sample program file illustrating GPIB/422 interface (H1000-IEEE) initialization, status verification and simple read and write operations. The system controller is comprised of a National Instruments AT-GPIB card installed in a IBM compatible pc. Program code was developed incorporating the National Instruments NI-488.2 Windows based application routines and compiled using the Microsoft Visual C++ compiler version 1.00.*/

```
#include <stdio.h>
#include <string.h>
/*WINDECL.H contains constants, declarations, and function prototypes.*/
#include <windecl.h>

// Function prototypes
int rdGPIB ( char*, int, int );
int rdSTRING ( char*, int );
int rdWATLOW ( char*, char*, int );

void main ( void )
{
    int TO422,H1000,    // device descriptors
        i;             // loop index
    char rd [ 80 ],     //read buffer
        HEAT_str [ 11 ] = { '\2', '=', ' ', 'S', 'P', '1', ' ', '1', '2', '3', '\3' },
        rdSTR [ 80 ];

    // open and configure gpib device(s)
    TO422 = ibdev ( 0, 5, 0, T10s, 1, 0x10 ); // GPIB/422 interface.
    H1000 = ibdev ( 0, 6, 0, T10s, 1, 0 );     // 422 devices.

    // output gpib device identifiers to screen.
    printf ( "GPIB/422 Device - %d\n", TO422 );
    printf ( "Watlow Device - %d\n", H1000 );

    // clear GPIB/422.
    ibclr (TO422);

    // configure RS422 protocol.
    ibwrt ( TO422, "spset 9600 o 7 1\n",17 );

    // retrieve RS422 protocol.
    ibwrt ( TO422, "spset\n", 6 );
    rdSTRING ( rdSTR, TO422 );
    printf ( "Serial Port Configuration - %s\n", rdSTR );

    // retrieve GPIB/422 status information, four strings.
```

```

ibwrt ( TO422, "stat n\n", 7 );           // status info request
printf ( "GPIB/422 status - " );
for ( i=0; i<4; i++ )
{
    rdSTRING ( rdSTR, TO422 );
    printf ( "%s ", rdSTR );
}

//set controller SP1 to 123 degrees,(write 'HEAT_str' to controller).
ibwrt ( H1000, "1\5", 2 );           // controller 1 link attempt.

rdGPIB ( rd, 2, H1000 );           // controller 1 link acknowledge.
if ( strcmp ( rd, "1\6\0" ) != 0 )
    printf ( "\tCOMMUNICATION ERROR\n" );

ibwrt ( H1000, HEAT_str, 11 );       // write 'HEAT_str' to controller.
printf ( "\n\nSET TEMP display should indicate 123 (123.0) degrees.\n\n" );

rdGPIB ( rd, 1, H1000 );           // controller 1 acknowledge.
if ( strcmp ( rd, "\6\0" ) != 0 )
    printf ( "\tCOMMUNICATION ERROR\n" );

// read WATLOW controller temperature display
ibwrt ( H1000, "1\5", 2 );           // controller 1 link attempt.

rdGPIB ( rd, 2, H1000 );           // controller 1 link acknowledge.
if ( strcmp ( rd, "1\6\0" ) != 0 )
    printf ( "\tCOMMUNICATION ERROR\n" );

ibwrt ( H1000, "\2? C1\3", 6 );       // request temperature reading.
rdGPIB ( rd, 1, H1000 );           // controller 1 acknowledge.
if ( strcmp ( rd, "\6\0" ) != 0 )
    printf ( "\tCOMMUNICATION ERROR\n" );

ibwrt ( H1000, "\4", 1 );           // end of transmission, send data.

rdWATLOW ( rd, rdSTR, H1000 ); // read data from controller.
printf ( "Current Temp.: %5s\r", rdSTR );

ibwrt ( H1000, "\6", 1 );           // acknowledge receipt of data.

rdGPIB ( rd, 1, H1000 );           // test for end of transmission
if ( strcmp ( rd, "\4\0" ) != 0 )
    printf ( "\tCOMMUNICATION ERROR\n" );
return;

```

```

}
/* GPIB/422 interface read function. Receives char array pointer, number of bytes to read, and
   device descriptor from calling function. Returns string data in char array rdSTR. String is
   terminated with null character '\0'. */

```

```

int rdGPIB ( char *rd, int bytecnt, int DEVICE )
{
    ibrd ( DEVICE, rd, bytecnt );           // read string
    rd [ bytecnt ] = '\0';                  // terminate string
    return ( 1 );
}

```

```

/* Data string read function. Inputs data strings terminated with carriage return/linefeed
   characters. Receives char array pointer and device descriptor from calling function. Data
   string is returned in rdSTR minus terminating characters. */

```

```

int rdSTRING ( char *rdSTR, int DEVICE )
{
    int count;
    char rd [ 1 ];

    for ( count=0; count<80; count++ )
    {
        rdGPIB ( rd,1,DEVICE);
        if ( rd [ 0 ] == 10 )                // test for line feed
            break;                          // exit condition
        else if ( rd [ 0 ] != 13 )           // test for carriage return
        {
            rdSTR [ count ] = rd [ 0 ]; // append character to 'rdSTR' string
            rdSTR [ count+1 ] = '\0'; // append 'null' to 'rdSTR' string
        }
    }
    return ( 1 );
}

```

```

/* Watlow controller read function. Checks for STX, reads data into 'rdWAT' until ETX
   character found, data string returned in null (\0) terminated rdWAT char array. Requires
   pointer to rd, rdWAT and device descriptor of Watlow controller. */

```

```

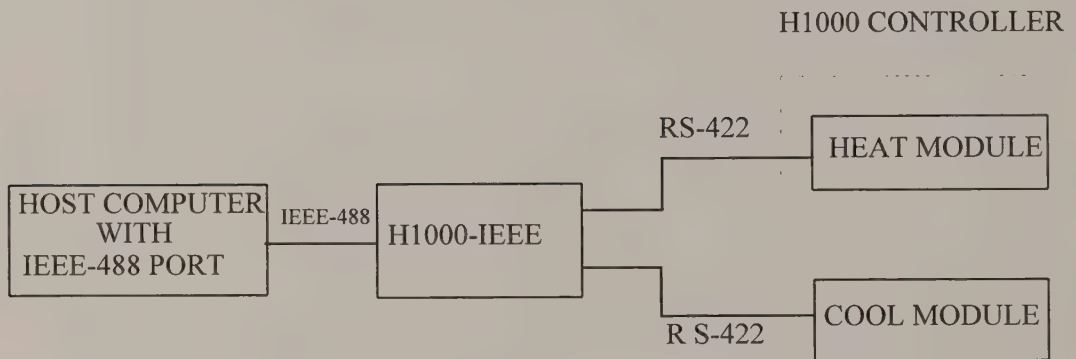
int rdWATLOW ( char *rd, char *rdWAT, int DEVICE )
{
    int count;
    rdGPIB ( rd, 1, DEVICE );
    if ( strcmp ( rd, "\2" ) != 0 )        // test for STX (start of text)
        return ( 0 );
}

```

```

for ( count=0; count<80; count++ )
{
    rdGPIB ( rd, 1, DEVICE );
    if ( strcmp ( rd, "\3" ) == 0 )    // test for ETX (end of text)
        break;                        // exit condition
    else if ( rd [ 0 ] != 13 )        // test for carriage return
    {
        rdWAT [ count ] = rd [ 0 ]; // append character to 'rdWAT' string
        rdWAT [ count+1 ] = '\0'; // append 'null' to 'rdWAT' string
    }
}
return ( 1 );
}

```



APPENDIX B
PROCEDURES AND CHECK OUT SHEETS

[illegible]

H1000 AC/DC Heat Controller Configuration and Test Procedure
A1011416 REV. A (12NOV97)

Purpose:

This procedure is intended to provide a sequence of steps to guide the proper configuration and functional test of the H1000 Series Heat Controllers (A1009795, A1010509-A/B).

Equipment:

- a. Cool module #1, A1010600.
- b. IBM compatible PC with an RS422 communications adapter and software.
- c. H1000 series hot chuck assembly, CHK8800-8C or equivalent.
- d. DC power supply assembly, DC-100-V1 (A1009795 only).
- e. RTD simulation adapter. (Simulates RTD and thermocouple input with known precision resistances).
- f. Cables as are required for proper connection of the system.

Reference Documents:

- a. A1009795, A1010509-A/B - Controller assembly documents.
- b. A1010460 - Series 1000 Thermal Chuck Systems Operation Manual.
- c. Watlow Controls Series 988 User's Manual.
- d. A1011417 - Heat Controller Check Out Sheet.

Procedure:

- 1.) Pull the Watlow control from it's housing and verify setting of input switches for RTD's (refer to the Watlow control User's Manual) Sw 1 & Sw 2 = OFF; Sw 3 = ON.
- 2.) Power up the controller and set the controller parameters as follows according to the controller part number (refer to the Watlow controller User's Manual for instructions on how to access each of the menus.)

Note: InPt: In1 = rt.d; and GLbL: C_F = C parameters MUST be set prior to entering the remainder of the configuration settings.

AC Controller Setup Parameters *** A1010509-A/B controllers only *** :

a.) INPUT menu options:

In1 = rt.d, rL1 = 12.0, rH1 = 405.0, CAL1 = 0.0, rtd1 = din, Ftr1 = 0, OFSt = no.

b.) OUTPUT menu options:

Ot1 = Ht, Prc1 = 4-20, Ot2 = Ht, HYS2 = 0.1, SP2c = dE, Ot3 = AL3n, AL3 = rAtE, A3Sd = HIgH, HYS3 = 0.1, LAt3 = nLa, SIL3 = OFF

c.) GLOBAL menu options:

C_F = C, FAIL = 0, Err = nLA, Ei1 = OFF, Anun = on, LoP = 0, HiP = 100, AtSP = 90, rP = OFF

d.) COMM menu options:

bAUd = 9600, dAtA = 7o, Prot = FULL, Addr = 1, intF = 422

e.) SYS menu options:

Ei1S = CLOS, A3LO = 0.0, A3HI = 555.0, AUt = OFF

f.) PidA menu options:

Pb1A = 12.0, rE1A = 0.42, rA1A = 0.25, Pb2A = 0.0

g.) SP2 = 3.0

h.) PLOC menu options:

loc = 2

DC Controller Setup Parameters *** A1009795 controllers only ***:

a.) INPUT menu options:

In1 = rt.d, rL1 = 12.0, rH1 = 400.0, CAL1 = 0.0, rtd = din, Ftr1 = 0, OFSt = no.

b.) OUTPUT menu options:

Ot1 = Ht, Prc1 = 0-10, Ot2 = AL2, AL2 = Pr1, A2Sd = High, LAt2 = LAt,

SIL2 = OFF, Ot3 = AL3N, AL3 = rAtE, A3Sd = High, HYS3 = 0.1, LAT3 = nLa, SIL3 = OFF

c.) GLOBAL menu options:

C_F = C, FAIL = 0, Err = nla, Ei1 = OFF, Anun = ON, LoP = 0, HiP = 100, AtSP = 90,
rP = OFF

d.) COMM menu options:

bAUd = 9600, dAtA = 7o, Prot = FULL, Addr = 1, intF = 422

e.) SYS menu options:

A2HI = 405.0, A3HI = 555.0

Ref: Ei1S = CLOS, A2LO = 0.0, A3LO = 0.0, AUT = OFF

f.) PIDA menu options:

Pb1A = 10.0, rE1A = 0.40, rA1A = 0.09

g.) PLOC menu options:

loc = 2

Control Module Function Checks:

3.) Connect the controller to the DC-100-V1 (A1009795 only), the cool module and the RTD simulation adapter. Turn ON the controller.

-Verify the control module displays the proper temperature for the RTD simulated input.

- 4.) Adjust the 'Set Temperature' of the controller to a value approximately 50 degrees above the indicated temperature and press the 'HEAT' button.
 - The 'HEAT' LED should turn ON, the other LED's should be OFF.
 - The 'ACTIVE' LED on the control module should be ON.
- 5.) Adjust the 'Set Temperature' of the cool module to a value less than its' indicated temperature and press the 'COOL' button.
 - The 'COOL' LED should turn ON and the other LED's should be OFF.
 - The 'ACTIVE' LED on the heat control module should be OFF and the 'ACTIVE' LED on the cool control module should turn ON.
- 6.) Press the 'STOP' button.
 - The 'STOP' LED should turn ON and the other LED's should be OFF.
 - The 'ACTIVE' LED's of both control modules should be OFF.
- 7.) Disconnect the RTD simulator from the controller.
 - The 'REMOTE' LED on the heat controller should be ON.
 - The temperature displays of the control modules should display '----'.
- 8.) Disconnect the cool module from the controller.

Power Supply Control - A1009795, DC Controller only

- 9.) Press the 'DSPY MODE' button on the control module until the '%OUT' LED of the control module turns ON.
 - The 'SET TEMP' display should display 0% and the DC supply voltage meter should indicate 0V.
- 10.) Press the 'HEAT' button and adjust the '%OUT' to 50%.
 - The DC supply voltage meter should indicate approximately 50V.
- 11.) Adjust the '%OUT' to 100%.
 - The DC supply voltage meter should indicate approximately 100V.
- 12.) Press the 'STOP' button.
 - The DC supply voltage meter should indicate 0V.

Burst Firing Card Calibration - A1010509-A/B, AC Controller only

Note: Refer to the Watlow SBL Card data sheet for detailed information concerning function and calibration of the Burst Firing Card (SBL).

- 13.) Power OFF and disconnect the controller from AC line voltage (unplug it). Remove the lower cover of the temperature controller to gain access to the Burst Firing Card (BFC) adjustment potentiometers.
- 14.) Plug in and turn ON the controller.
 - The '%OUT' LED of the control module should be ON.
- 15.) Press the 'HEAT' button.
 - The 'SET TEMP' display should read 0% and the 'ON' LED of the BFC should be OFF.
 - If the LED is flashing, adjust the 'BIAS' potentiometer until the LED is completely OFF.
- 16.) Adjust the '%OUT' of the control module to 100%.

- The 'ON' LED of the BFC should be fully ON, if it is flashing adjust the 'GAIN' potentiometer until the LED is fully ON.
- 17.) Adjust the '%OUT' of the control module to 95%.
 - The 'ON' LED of the BFC should be rapidly flashing.
- 18.) Adjust the '%OUT' of the control module to 5%.
 - The 'ON' LED of the BFC should be flashing periodically, approximately every 2-3 seconds.
- 19.) Repeat the previous steps until the BFC is properly adjusted.
- 20.) Press the 'STOP' button.
 - The 'ON' LED should be completely OFF.
- 21.) Power OFF the controller.

Over-Temperature Protection Set Point Verification

- 22.) Connect the Thermocouple Calibrator to the thermocouple input of the controller (this will require a special adapter) and set the calibrator for type K thermocouples. Power ON the controller and inject a calibration temperature of 50 degrees C into the controller.
 - The 'LIMIT' LED should be OFF, if ON press the 'RESET' switch to clear and the LED should turn OFF.
- 23.) Inject a calibration temperature of 425 degrees C into the controller.
 - The 'LIMIT' LED should be OFF.
- 24.) Inject a calibration temperature of 490 degrees C into the controller.
 - The 'LIMIT' LED should be ON.
- 25.) Inject a calibration temperature of 425 degrees C into the controller and press the 'RESET' switch.
 - The 'LIMIT' LED should turn OFF.
- 26.) Power OFF the controller and disconnect the Thermocouple Calibrator.

RS422 Communication Port Test

- 27.) Connect the controller to the RS422 communication adapter / PC. Connect the RTD simulator to the controller. Power ON the controller and the PC.
- 28.) Using 'PcTc' or other RS422 communication software verify proper communication between the controller and the PC by successfully setting and reading 'SP1' (set point 1) of the Watlow control.
- 29.) Power OFF the controller and the PC and disconnect the communication adapter from the controller.

Chuck Heating Test

- 30.) Connect the hot chuck to the controller. Power ON the controller.
- 31.) Adjust the 'SET TEMP' to a value approximately 50 degrees C above the indicated temperature of the chuck. Press the 'HEAT' button.
 - The 'HEAT' LED should turn ON and the chuck should begin to heat (the indicated temperature of the chuck should begin to increase).
- 32.) Allow the chuck temperature to increase approximately 10-15 degrees C.

33.) Press the 'STOP' switch.

- The 'HEAT' button should turn OFF, the 'STOP' button ON, and the chuck should gradually stop heating

34.) Power OFF the controller.

Test Completion

35.) Disconnect the controller from any test equipment and replace the covers if necessary.

36.) Stamp the back of the controller with your 'Test Stamp', somewhere near the voltage selection switches on the rear panel

H1000 AC/DC Heat Controller Checkout Sheet
A1011417 REV. A (11NOV97)

1. Controller setup parameters properly configured. _____
 - a. AC controller only (A1010509-A/B) Record the following menu settings;
INPUT menu: rHI = _____
PidA menu: Pb1A = _____ rE1A = _____ rA1A = _____ Pb2A = _____
SP2 = _____
PLOC menu: loc = _____
 - b. DC controller only (A1009795) Record the following settings;
PidA menu: Pb1A = _____ rE1A = _____ rA1A = _____ Pb2A = _____
PLOC menu: loc = _____
2. Completed Control Module Function Check. _____
3. Completed Power Supply Control Check (A1009795 only). _____
4. Burst Firing Card Calibrated (A1010509-A/B only) _____
5. Over Temperature Set Point checked _____
6. RS422 Communication Port Test Completed _____
7. Chuck Heating Operational Test Completed _____

Controller Model #: _____ Date: _____

Test Technician: _____

QC Representative: _____

H1000 Cool Module #1 Configuration and Test Procedure

Purpose:

This procedure is intended to provide a sequence of steps to guide the proper configuration and functional test of the A1010600 assembly (H1000 Series Cool Module #1).

Equipment:

- a. SRV / Cool module test fixture.
- b. IBM compatible pc with an RS422 communications adapter and software.
- c. Cables: A1010607 - SRV power cable, or equivalent.
A1010565 - Heat to cool module cable, or equivalent.
A1007713 - Line cord, or equivalent.
A1008947 - H1000-RS232 module to controller cable, or equivalent.

Reference Documents:

A1010600 - Assembly, Cool Module #1.
A1009777 - Series 1000 Thermal Chuck Systems Operation Manual.
Watlow Controls Series 988 User's Manual.

Procedure:

1.) Connect the module to the test fixture and the computer communication adapter. Set the switches on the test fixture to 'OFF'. Pull Watlow controller from it's container and set input switches for RTD.

2.) Turn on the test fixture and set the controller parameters as follows (refer to the Watlow controller User's Manual for instructions on how to access each of the menus).

Note: InPt: In1 - rtd; and GLbL: C_F - C parameters MUST be set prior to entering the remainder of the configuration settings.

- a.) InPt: In1 - rtd
- b.) GLbL: C_F - C
- c.) InPt: In1 - rtd; rL1 - 12; rH1 - 399; CAL1 - 0; rtd1 - din; Ftr1 - 0
- d.) OtPt: Ot1 - CL; Prc1 - 4-20; Ot2 - CL; HYS2 - 1; SP2c - dE; Ot3 - AL3n; AL3 - rATE; A3Sd - HIGH; HYS3 - 1; LAt3 - nLA; SIL3 - OFF
- e.) GLbL: C_F - C; FAIL - 0; Err - nLA; Ei1 - OFF; Anun - ON; LoP - -100; HiP - 0; AtSP - 90; rP - OFF
- f.) COM: bAUd - 9600; dATA - 7o; Prot - FULL; Addr - 2; IntF - 422
- h.) SYS: EiS - CLOS; A3LO - -555; A3HI - 555; AUt - OFF
- i.) PidA: Pb1A - 14; rE1A - 0.00; rA1A - 0.00; Pb2A - 0
- g.) SP2 - 0

- 3.) Press the 'PURGE' switch the module.
 - The switch should latch 'ON'.
 - The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should be 'ON'.
- 4.) Press the 'PURGE' switch again.
 - The switch should release 'OFF'.
 - The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should be 'OFF'.
- 5.) Set 'SET TEMP' to 30 degrees and rotate the 'RTD INPUT' potentiometer until the controller temperature display reads ~ 50 degrees.
 - The 'ACTIVE' and 'Cool Valve' l.e.d.'s should be 'OFF'.
- 6.) Switch the 'EVENT 1' switch 'ON'.
 - The 'ACTIVE' and 'Cool Valve' l.e.d.'s should be 'ON'.
 - The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should be 'OFF'.
- 7.) Switch the 'EVENT 1' switch 'OFF'.
 - The 'ACTIVE' and 'Cool Valve' l.e.d.'s should be 'OFF'.
 - The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should turn 'ON' and remain on for a duration of 55 to 65 seconds.
- 8.) Switch the 'EVENT 1' switch 'ON'. Rotate the 'RTD INPUT' pot. counter clockwise until the temperature display reaches the 'SET TEMP'.
 - The 'ACTIVE' and 'Cool Valve' l.e.d.'s should turn 'OFF'.
 - The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should turn 'ON' and remain on for ~ 60 seconds.
- 9.) Rotate the 'RTD INPUT' pot. fully counter clockwise.
 - The temperature display should contain " - - - - ".
 - The 'REMOTE' l.e.d. should be 'ON'.
 - The 'SET TEMP' window should display "0".
- 10.) Adjust the 'SET TEMP' to verify the minimum and maximum set temp points.
 - Minimum 'SET TEMP' should be 12 degrees.
 - Maximum 'SET TEMP' should be 399 degrees.
- 11.) Using PcTC or other communications software, verify the proper function of the modules RS422 communications by reading and setting the 'SET TEMP'.
- 12.) As a final step set the PLOC: LOC to 2.

Cool Module #1 Test - Check Out Sheet

Procedure:

Complete this check out sheet referencing the H1000 Cool Module #1 Configuration and Test Procedure (doc. #A1010813).

- 1.) Verify proper configuration of the controller as specified by the cool module #1 configuration and test procedure. _____
- 1.) Verify proper operation of the manual 'PURGE' switch _____
- 2.) Verify proper controller cooling operation (RTD input , event 1 input, cooling and purge output). _____
- 3.) Verify 'Purge Timer' output duration of 55 - 65 seconds, and purge lamp works. _____
- 4.) Verify 'REMOTE' l.e.d. works. _____
- 5.) Verify max and min 'SET TEMP' points
max _____
min _____
- 6.) Verify proper RS422 communications. _____
- 7.) PLOC set to 2. _____

Work Order # _____

Test Technician: _____ Date: _____

Q.C. Personnel: _____ Date: _____

DC 100 POWER SUPPLY Assembly Test

Document # A1011432, Rev. B

This test sheet should follow the DC power Supply through to the finished good level assembly.

Equipment required:

- a.) 8" Test puck assembly
- b.) A1009795 assy. or equivalent.
- c.) Misc. test leads or test assy.'s as required.
- d.) Multi

Initial and incoming inspection Power supply test

Visually inspect for damage due to shipping, improper packaging, or assembly. Check the internal transformer wiring to insure correct voltage set up. With test wires connect 8" test chuck assembly and to the Red and Black output Banana Jacks on the back of the DC supply. Connect Multimeter as volt meter to rear outputs also. Turn the front panel Voltage and amperage controls fully counterclockwise (off). Turn on DC power supply the front panels meters should display no load conditions. Slowly turn the voltage control knob clockwise. The voltage should increase as the knob is turned and the DC supply current should also increase based on the load resistance connected to the outputs (8" 120 puck is rated 1350 watts at 120 V or nominally 10.6 ohms). The voltage and amperage on the rear output should agree with the voltage and amperage displayed on the front panel meters. Turn off unit and reconnect multimeter as ampmeter and repeat test.

Verify correct operation of the supply in this manner and record the displayed current at the following voltages:

DC amps @ 20 VDC: _____	Remote Volts _____ Amps _____
DC amps @ 60 VDC: _____	Remote Volts _____ Amps _____
DC amps @ 100 VDC: _____	Remote Volts _____ Amps _____

Part # _____ Purchase Order # _____

Test Technician: _____ Date: _____

Q.A. Representative: _____ Date: _____

Modified DC Power supply test

With shop test cables and DC Heat controller (assy A1009795) connect DC supply 8" to test chuck assembly. Turn on Heat Controller and DC power supply. Unlock the heat controller (if necessary and switch it to % output operation. Slowly increase the Heat Controllers output using the increase arrow button. The voltage should increase as the arrow button is depressed and the DC supply current should also increase based on the load resistance connected to the outputs (8" 120 puck is rated 1350 watts at 120 V or nominally 10.6 ohms).

Verify correct operation of the supply in this manner and record the displayed current at the following voltages:

DC amps @ 20 VDC: _____
DC amps @ 60 VDC: _____
DC amps @ 100 VDC: _____

Assembly # _____ Work order # _____

Test Technician: _____ Date: _____

Q.A. Representative: _____ Date: _____

DC 100 POWER SUPPLY Assembly Test

Document # A1011432, Rev. B

DC-100 -Vx Power supply test

After Power supply is mounted into to cabinet or table. Connect it to the proper power outlet and test. Test with shop test cables, Shop DC Heat controller (assy A1009795), and 8" to test chuck assembly. Turn on Heat Controller and DC power supply. Unlock the heat controller (if necessary and switch it to **% output** operation. Slowly increase the Heat Controllers output using the increase arrow button. The voltage should increase as the arrow button is depressed and the DC supply current should also increase based on the load resistance connected to the outputs (8" 120 puck is rated 1350 watts at 120 V or nominally 10.6 ohms).

Verify correct operation of the supply in this manner and record the displayed current at the following voltages:

DC amps @ 20 VDC: _____

DC amps @ 60 VDC: _____

DC amps @ 100 VDC: _____

_____ Adjust Cool Module "set temperature" to a c valve lower than displayed temperature. Press "COOL" button, cool module "ACTIVE" LED should turn "ON". Press "STOP" button, cool moduel "ACTIVE" LED should turn "OFF."

_____ Check that controller temperature indicators agreed with standard readings of shop chuck.

Assembly # _____ Work order # _____

Test Technician: _____ Date: _____

Q.A. Representative: _____ Date: _____

Document # A1011113 Rev. A
HEAT EXCHANGER Assembly Test

Equipment required: a.) SRV / Cool module test jig.
b.) 0 - 30 psi pressure gauge.
c.) A1010607 cable assy. or equivalent.
d.) "Graduated cylinder"
e.) Misc. hose assy.'s as required.

Check Control Functions:

The Heat Exchanger is a large Service module (SRV1) with a self contained water supply. Connect the SRV tester to the Heat Exchanger. The "PURGE" valve when open (on) connects the Air Inlet fitting to the Chuck Supply fitting via a regulator and a check valve. The "COOL" valve when open (on) connects the heat exchanger output (outlet) to the Chuck Supply fitting. These valves under normal systems control are never energized at the same time. The SRV tester provides manual control of these valves. Ensure that The correct valves are actuated by the SRV tester. Cycle the Heat exchanger power to insure that heat exchanger fan and Pump energize.

Proper valve operation: _____

Heat exchanger operation: _____

Pressure Regulator Setting:

Connect house air (> 50 psi) to the Air Supply (inlet fitting) and the pressure gauge to the Chuck Supply (output fitting). Check for leaks using a soapy water solution if necessary. Open the "PURGE" valve, fix any leaks, and adjust the regulator as necessary to provide 13 - 15 psig.

Regulated Air Pressure: _____

No Air Leaks: _____

Check plumbing Leaks:

Connect two short hose assemblies between the radiator and chuck fittings (Radiator Supply to Radiator Return, and Chuck supply to Chuck return). Close "PURGE" valve, and open "COOL" Valve. Place a block under one corner to make the pump inlet the lowest point in the assembly. **Fill reservoir with water.** Cycle pump until water continuously flows back to reservoir.

Check for leaks and fix if necessary

No Leaks: _____

Water flow verification:

Close "COOL" valve. Check Radiator supply flow (**use minimum 3/16 I.D. Tubing**). It should be around 18.75 gallons/hour (1.25 quarts/minute). Record flow rate. Reconnect Radiator supply to Radiator return.

Open "COOL" valve. Check Chuck supply flow. It should be around 18.75 gallons/hour (1.25 quarts/minute). Record flow rate. Reconnect Chuck Supply to Chuck return.

Radiator Flow Rate : _____ QT/MIN.

Chuck Flow Rate : _____ QT/MIN.

Allow unit to run overnight and check again next day for leaks and proper operation. If only one unit then leave SRV test connected and "COOL" valve on. This is not necessary when more than one unit is to be burned in overnight.

Drain/ siphon water from unit.

Assembly # _____ Work order # _____

Serial # _____

Test Technician: _____ Date: _____

Q.A. Representative: _____ Date: _____

H1000 Thermal Chuck Temperature Control System Check
Final Integration
ambient to 400 deg C or 0 deg C to 400 deg C

Date: _____ S/O: _____ Heat s/n: _____ Cool s/n: _____
 Chuck s/n _____ Options s/n _____
 QC init: _____

Check to insure Assembly and Test documentation is Present.

COMPONENT	CHECKOUT SHEET PRESENT If not RETEST is REQUIRED	CHECKOUT SHEET No.	REF DOCUMENT	Test Technician	QC.
Heat Controller		A1011417	A1011416		
DC 100 Supply		A1011432			
Chuck Assembly		A1011024			
Cool Module 1		A1011021	A1010813		
Cool Module 2		A1011214	A1011213		
Service Module		A1010812			
Heat Exchanger		A1011113			
Computer Interfaces		A1011418			

Heat Temperature Controller checks

_____ On 0°C. systems the H1000 AC/DC Heat controller the rL1 prompt in the Input menu should be reset Input low from 12.0 to 0.0 rL1 = 12.0 to rL1 = 0.0

_____ If system is Heat only then ensure Hoses are provided for customer to plumb for Radiator cooling. (This would be Part No. A1010602 & A1010605)

Thermal chuck:

_____ Chuck has correct cooling fittings for proper plumbing option. (A1008449 is used on chucks with -65°C plumbing option. Cooling hose length will need to be shortened approximately 1/2")

_____ Chuck plumbing hoses not crimped shut by improper installation.

_____ Chuck plumbing hoses connected properly (reference Manual for proper installation.

Cooling Option:

_____ Adjust flow in SRV module to 1.25 quarts/minute when using add on chiller.

_____ Adjust air pressure and purge time when using add on chiller to prevent overflows in chiller reservoir.

Basic H1000 / C1000 System Operation

- _____ If system is Heat only then ensure Hoses are provided for customer to plumb for Radiator cooling. (This typically would be Part No. A1010602 & A1010605)
- _____ Purge is activated when power is turned on (> 60 seconds and < 100 seconds).
- _____ Power, Purge, Heat, Cool, and Stop buttons work.
- _____ "Error" indication (----) is triggered when the T/C cable is disconnected.
- _____ Active lights are on when modules are heating or cooling.
- _____ Display modes work correctly: set temperature, deviation from set temperature, % power output, temperature unit of measurement.
- _____ Indicated Chuck Temperature (ICT) for heat module displays with resolution of 0.1 deg C.
- _____ Indicated Chuck Temperature (ICT) for cool module (ambient system) displays with resolution of 1 deg C.
- _____ Indicated Chuck Temperature (ICT) for cool module (0 deg C system) displays with resolution of 0.1 deg C.
- _____ Test heat mode:
- _____ Check that Heat Controller maintains temperature at mid-range (175 to 200 deg C); check for no overshoots and that system stabilizes at the set temperature.
- _____ Check that Chuck radiator is working (Can be touched with out burning)
- _____ Check that Heat Controller maintains temperature at max temperature; check for no overshoots and that system stabilizes at the set temperature.
- _____ Check that Chuck radiator is working (Can be touched with out burning)
- _____ Test cool mode to min temperature from max temperature.
- _____ No coolant or air leaks at min or max temperature; check connections at SRV1 plumbing module, station rear panel, hot chuck, and at air and coolant sources.
- _____ Purge is activated when the indicated temperature reaches cool set temperature (ambient system).
- _____ Purge is activated when leaving "COOL" mode (0°C. systems).
- _____ Check and record "OVERTEMPERATURE PROTECTION " value _____ (between 425 and 485°C)

Calibration Verification Procedure:

CAL1 can be set to a value other than zero (0.0). To determine if this is necessary fill in the Calibration Verification chart. Record the temperature controllers indication at ambient, 100°C., 200°C., 300°C., and 400°C. Record their readings at 0°C. when Systems allow it. Record the Heat Controllers temperature as RTD1, the cool controller as RTD2, and the internal type K thermocouple as the T/C.

Ambient:	RTD1 _____, RTD2 _____, t/C _____
0C:	RTD1 _____, RTD2 _____, t/C _____
100 C:	RTD1 _____, RTD2 _____, t/C _____
200 C:	RTD1 _____, RTD2 _____, t/C _____
300 C:	RTD1 _____, RTD2 _____, t/C _____
400 C:	RTD1 _____, RTD2 _____, t/C _____

Compare these readings. At ambient and 0°C the Heat and Cool modules should read within 0.1°C of each other and not more than 1.0°C at 400°C. The RTD readings should also be within 4°C of the internal T/C. When discrepancies are noted determine the cause and repair.

The thermal chuck assemblies are supplied with 2 high isolation RTD assemblies. The RTD elements are three wire IEC 751 Class A platinum RTD assemblies which conform to the DIN curve (.00385 ohms/degree C.) and are 100 ohms at 0 degrees C. Both RTD elements are wired into the current connectors and an adapter cable exists that can swap the RTD between the two controllers for troubleshooting purposes. Also some fixed Resister T/C adapter plugs are also available to help determine if the Controllers are "in calibration". Some typical resistance's to temperature are: 80.31 ohms is -50°C, 100.00 ohms is 0°C, 119.40 ohms is 50°C, 138.51 ohms is 100°C, and 247.09 ohms is 400°C. The Watlow Controllers should be returned to the factory whenever their calibration is determined to be greater than 1.0°C in error.

Any small discrepancy that is in a nature of a "fixed offset" can be adjusted out using the CAL1 (INPUT MENU). Record any offsets programmed.

Controller _____ CAL1 _____
Controller _____ CAL1 _____

To be performed by QC department:

Calibration Verification:

____ Compare these readings. At ambient and 0°C the Heat and Cool modules should read within 0.1°C of each other and not more than 1.0°C at 400°C. The RTD readings should also be within 4°C of the internal T/C.

Ambient:	RTD1 _____,	RTD2 _____,	t/C _____
0C:	RTD1 _____,	RTD2 _____,	t/C _____
100 C:	RTD1 _____,	RTD2 _____,	t/C _____
200 C:	RTD1 _____,	RTD2 _____,	t/C _____
300 C:	RTD1 _____,	RTD2 _____,	t/C _____
400 C:	RTD1 _____,	RTD2 _____,	t/C _____

____ Test heat mode to max temperature from min temperature. Fill in the time to temperature chart (A1011220) in 1 minute intervals.

____ Test cool mode to min temperature from max temperature. Fill in the time to temperature chart (A1011220) in 1 minute intervals.

____ Give time to temperature charts to Marketing's Thermal Systems Product Manager; there should be two (2) tests.

Additional Notes (Calibration offsets, system configuration, Prober, etc.):

APPENDIX A

STANDARD CONTROLLER SETTINGS

NOTE:

*CAL1 is calibration offset for matching temp displays between Heat & Cool Module. The starting value for CAL1 is zero (0). See page 2 Calibration Verification Procedure.

INPUT for an AC Controller, ambient to 400 deg C:

In1 = rt.d, rL1 = 12.0, rH1 = 405.0, CAL1 = 0.0*, rtd1 = din, Ftr1 = 0, OFSt = nO

INPUT for an AC Controller, 0 deg C to 400 deg C:

In1 = rt.d, rL1 = 0.0, rH1 = 405.0, CAL1 = 0.0*, rtd1 = din, Ftr1 = 0, OFSt = nO

INPUT for a DC Controller, ambient to 400 deg C:

In1 = rt.d, rL1 = 12.0, rH1 = 400.0, CAL1 = 0.0*, rtd1 = din, Ftr1 = 0, OFSt = nO

INPUT for a DC Controller, 0 deg C to 400 deg C:

In1 = rt.d, rL1 = 0.0, rH1 = 400.0, CAL1 = 0.0*, rtd1 = din, Ftr1 = 0, OFSt = nO

OUTPUT for an AC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:

Ot1 = Ht, Prc1 = 4-20, Ot2 = Ht, HYS2 = 0.1, SP2c = dE, Ot3 = AL3N,
AL3 = rAtE, A3Sd = High, HYS3 = 0.1, LAT3 = nLa, SIL3 = OFF

OUTPUT for a DC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:

Ot1 = Ht, Prc1 = 0-10, Ot2 = AL2, HYS2 = 0.1, AL2 = Pr1, A2Sd = High,
LAT2 = LAt, SIL2 = OFF, Ot3 = AL3N, AL3 = rAtE, A3Sd = High, HYS3 = 0.1,
LAT3 = nLa, SIL3 = OFF

GLOBAL for an AC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:

C_F = °C, FAIL = 0, Err = nla, Ei1 = OFF, Anun = ON, LoP = 0, HiP = 100,
AtSP = 90, rP = OFF

GLOBAL for a DC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:

C_F = °C, FAIL = 0, Err = nla, Ei1 = OFF, Anun = ON, LoP = 0, HiP = 100,
AtSP = 90, rP = OFF

COMM, ambient to 400 deg C or 0 deg C to 400 deg C

bAUd = 9600, dAtA = 7o, Prot = FULL, Addr = 1, intF = 422

SYS for an AC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:

A3HI = 555.0

Ref: Ei1S = CLOS, A3LO = 0.0, AUT = OFF

SYS for a DC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:

A2HI = 405.0, A3HI = 555.0

Ref: Ei1S = CLOS, A2LO = 0.0, A3LO = 0.0, AUT = OFF

PIDA for an AC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:
Pb1A = 12.0, rE1A = 0.42, rA1A = 0.25, Pb2A = 0.00

PIDA for a DC Controller, ambient to 400 deg C or 0 deg C to 400 deg C:
Pb1A = 10.0, rE1A = 0.40, rA1A = 0.09

_____ **PLOC** is set to 2 (user is locked out from changing system level parameters)

_____ **SP2** = 3.0 (AC Controller only, ambient to 400 deg C or 0 deg C to 400 deg C)

Cool Temperature Controller checks

_____ Check setups for appropriate cool module:

INPUT, ambient to 400 deg C:

In1 = rt.d, rL1 = 12, rH1 = 399, CAL1 = 0*, rtd1 = din, Ftr1 = 0, OFSt = nO

INPUT, 0 deg C to 400 deg C:

In1 = rt.d, rL1 = 0.0, rH1 = 399.0, CAL1 = 0.0*, rtd1 = din, Ftr1 = 0, OFSt = nO

OUTPUT, ambient to 400 deg C:

Ot1 = CL, Prc1 = 4-20, Ot2 = CL, HYS2 = 1, SP2C = dE, Ot3 = AL3n,
AL3 = rAtE, A3Sd = high, HYS3 = 1, LAt3 = nLA, SIL3 = OFF

OUTPUT, 0 deg C to 400 deg C:

Ot1 = CL, Prc1 = 4-20, Ot2 = CL, SP2C = dE, Ot3 = AL3n,
AL3 = dEl, A3Sd = high, HYS3 = 0.1, LAt3 = nLA, SIL3 = OFF

GLOBAL, ambient to 400 deg C:

C_F = C, FAIL = 0, Err = nLA, Ei1 = off, anun = ON, LoP = -100, HiP = 0,
AtSP = 90, rP = OFF

GLOBAL, 0 deg C to 400 deg C:

C_F = C, FAIL = 0, Err = nLA, Ei1 = off, anun = OFF, LoP = -100, HiP = 0,
AtSP = 90, rP = OFF

COMM, ambient to 400 deg C or 0 deg C to 400 deg C:

bAUd = 9600, dAtA = 7o, Prot = FULL, Addr = 2, intf = 422

SYS, ambient to 400 deg C:

A3HI = 555

Ref: Ei1S = CLOS, A3LO = -55, AUT = OFF

SYS, 0 deg C to 400 deg C:

A3HI = 1.5

Ref: Ei1S = CLOS, A3LO = -55.0, AUT = OFF

PIDA, ambient to 400 deg C:

Pb1A = 14.0, rE1A = 0.00, rA1A = 0.00, Pb2A = 0.0

PIDA, 0 deg C to 400 deg C:

Pb1A = 4.0, rE1A = 0.20, rA1A = 0.05, Pb2A = 4.0, rE2A = 0.20, rA2A = 0.05,
CT2A = 10.0

_____ **PLOC** is set to 2 (user is locked out from changing system level parameters)

_____ **SP2** = 0, ambient to 400 deg C

_____ **SP2** = -2.0, 0 deg C to 400 deg C

APPENDIX B

VERSION "1" O DEGREE COOLING MODULE (A1010760).

Original modules used output 2 to control the cooling valve and alarm output 3 to control the Purge interval timer.

The current modules use output 1 for the cooling valve and output 2 for the purge interval timer. requiring the SP2 = 25; **PIDA**: Pb2A = 0.0; **INPUT**: rL1 = -2.0, **OUTPUT**: AL3 = rAtE, **GLOBAL**: anun = ON, **SYS**: A3HI = 555.5

Original Settings:

NOTE:

*CAL1 is calibration offset for matching temp displays between Heat & Cool Module. The starting value for CAL1 is zero (0). See page 2 Calibration Verification Procedure.

INPUT, 0 deg C to 400 deg C:

In1 = rt.d, rL1 = 0.0, rH1 = 399.0, CAL1 = 0.0*, rtd1 = din, Ftr1 = 0

OUTPUT, 0 deg C to 400 deg C:

Ot1 = CL, Prc1 = 4-20, Ot2 = CL, SP2C = dE, Ot3 = AL3n,
AL3 = dEl, A3Sd = high, HYS3 = 0.1, LAt3 = nLA, SIL3 = OFF

GLOBAL, 0 deg C to 400 deg C:

C_F = C, FAIL = 0, Err = nLA, Ei1 = off, anun = OFF, LoP = -100, HiP = 0,
AtSP = 90, rP = OFF

COMM, ambient to 400 deg C or 0 deg C to 400 deg C:

bAUd = 9600, dAtA = 70, Prot = FULL, Addr = 2, intf = 422

SYS, 0 deg C to 400 deg C:

A3HI = 1.5

Ref: Ei1S = CLOS, A3LO = -55.0, AUT = OFF

PIDA, 0 deg C to 400 deg C:

Pb1A = 4.0, rE1A = 0.20, rA1A = 0.05, Pb2A = 4.0, rE2A = 0.20, rA2A = 0.05,
CT2A = 10.0

_____ **PLOC** is set to 2 (user is locked out from changing system level parameters)

_____ **SP2** = 0.0, 0 deg C to 400 deg C

SRV Module Assembly Test

Equipment required:

- a.) SRV / Cool module test jig.
- b.) 0 - 30 psi pressure gauge.
- c.) A1010607 cable assy. or equivalent.
- d.) 'Graduated cylinder'.
- e.) Misc. hose assy.'s as required.

Leak test:

Check the internal assembly of the SRV thoroughly for leaks by connecting house air (> 50 psi) to each of the supply inlets and inspect for leaks using soapy water solution if necessary, check with the valves closed and open. As a final test supply water (> 30 psi) to each of the supply inlets and visually inspect for leaks with valves both open and closed.

No Leaks: _____

Pressure Regulator Settings:

Connect house air (> 50 psi) to each of the supply inlets and the pressure gauge to the chuck output. Open the appropriate valve and adjust each of the regulators as necessary to set the regulated air pressure to 13 - 15 psig and the regulated water pressure to 14 - 16 psig.

Regulated Air Pressure: _____

Regulated Water Pressure: _____

Water flow verification:

Supply water to the coolant supply inlet and measure the quantity of water supplied per minute from the chuck output using the 'graduated cylinder'. Adjust the water pressure regulator as necessary to achieve a minimum flow rate of 18.75 gallons / hour (1.25 quarts / minute). Measure with proper attachments i.e. graduated cylinder and 3 ft. length 3/16 or greater i.d. tubing.

Flow Rate : _____

Assembly # _____ Work order # _____

Test Technician: _____ Date: _____

Q.A. Representative: _____ Date: _____

**CALIBRATION PROCEDURE
FOR
ADVANCED CALIBRATION OF H1000 THERMAL CHUCK SYSTEMS
(TO EXTERNAL STANDARDS)**

PURPOSE:

The **Offset** (Calibration) Program in our temperature controllers is a tool that provides the end user with the capability to alter the calibration of the thermal chuck systems as received. More importantly the **Offset** (Calibration) Program in the temperature controllers allows calibration of the system to an external standard such as surface contact RTDs, thermocouples, temperature sensing wafers, non contact IR probes, etc.

HISTORY:

The calibrations of the factory systems are performed in the following fashion. First the electronic controllers are calibrated to an external standard that adjusts their internal A/D converters to their RTD look up tables. This calibration service is provided by another vendor. Second these electronic controllers are connected through the thermal control system to the thermal chucks and that calibration is checked when connected to the thermal chucks RTD. Each thermal chuck has two high isolation RTD assemblies and two high isolation type K thermocouples built in the assembly. The RTD elements are three wire, IEC 751 Class A, platinum RTD assemblies that conform to the DIN curve (.00385 ohms/degree C.) and are 100 ohms at 0 degrees C. Both RTD elements are wired into the current connectors with one of the type K thermocouples. The calibration of the controllers to the RTDs is checked against the internal thermocouple. A breakout connector is inserted in line with the system T/C cable that allows access to one of the two type K thermocouples. The system is operated to several temperatures. The system is allowed to soak at each temperature. The controller RTD readings and the thermocouple readings are recorded at each setting. After all the readings are reviewed it is determined what offset if necessary should be implemented. The factory tolerances for dual controller offset calibrations are 0.1°C at 0°C. (or ambient) and less than 1°C at 400°C. These factory offsets are considered allowable due to the calibration tolerances of both the electronic controllers and the Class A RTD assemblies. Our allowable factory tolerance is more closely held than the IEC 751 tolerances for a Class A platinum RTD. That is we reject RTD assemblies that will not allow these tolerances to be held even though they meet the Class A tolerances.

The **Offset** (Calibration) Program in the temperature controllers can allow even tighter tolerancing of the dual controllers to the RTDs when required by the end user. More importantly the **Offset** (Calibration) Program in the temperature controllers can also be used when it is desired to calibrate the system to an external standard such as surface contact RTDs, thermocouples, temperature sensing wafers, non contact IR probes, etc. To uses this feature the

system should be operated to several temperatures (at least 5 temperatures across the desired range of performance and one at 400°C) and allowed to soak at each temperature. The temperature displayed on each controller should be recorded versus the external standards at each temperature setpoint. Once the measurements are reviewed the necessary offsets can be calculated and entered into the controllers.

1.0 OVERVIEW:

ACCESSING THE INTERNAL MENUS

Settings for the H1000 and HC1000 Thermal Chuck temperature controllers are factory adjusted. It is always important to remember that when entering into system menus that there are operating modes that can be inadvertently accessed (and altered) that will result in system failure and possible hardware damage. **It is not recommended that anyone but factory authorized personnel access the internal Menus.**

To access the **Offset** (Calibration) Program feature (OFSt) we need to enter into the controllers internal menus. The **Offset** (Calibration) Program feature is nested in the "INPT" (input) menu which is nested in the "SEt" (Setup) menus. To access the "SEt" menu depress the up and down arrow buttons simultaneously and hold for approximately three seconds. The red setpoint display will read "SEt" when it is reached. The upper display should show **InPt**. There are four menus under the SEt prompt: InPt (Input menu), OtPt (Output menu), gLbL (Global menu), and COM (Communications menu). Use the Up or Down key to select a the desired menu and the hidden key between the Up button and DSPY MODE button to advance through the selected menu. Once in the selected menu the Up and down keys are used to select options inside of the selected menu. Depressing the DSPY MODE button once returns the controllers to normal operation maintaining any changes made in the internal menus. (Ref. Fig. 1)

2.0 THE "OFSt" OFFSET (CALIBRATION) PROGRAM

Ten user programmable "CALIBRATION" offset points have been added . These points allow the user to select a CALIBRATION offset for up to 10 different points between -60C and 500 degrees C and when these offset calibrations are active the input value will be converted linearly between the nearest 2 points. In the The first variable is the calibration setpoint and the second would be the offset for that setpoint.

The first setpoint defaults to 25.0, the last setpoint point defaults to +500. 0. All offset points default to zero offset. The programmable setpoint(Pt) and offset (PO) resolution is 0.1 degrees (0 degrees for ambient cooling options). These calibration setpoints have default values but are user selectable/programable. For example. 'Pt01' defaults to 25.0 but the user can change 'Pt01' to -35.0 or any other value less than the next user setpoint down to -60.0

The entry method of the offset

Upper display = Yes/No/Clr

Lower display = 'OFSt'

Default = no

This is where the calibration offsets can be entered when desired. No means no custom offsets are active.

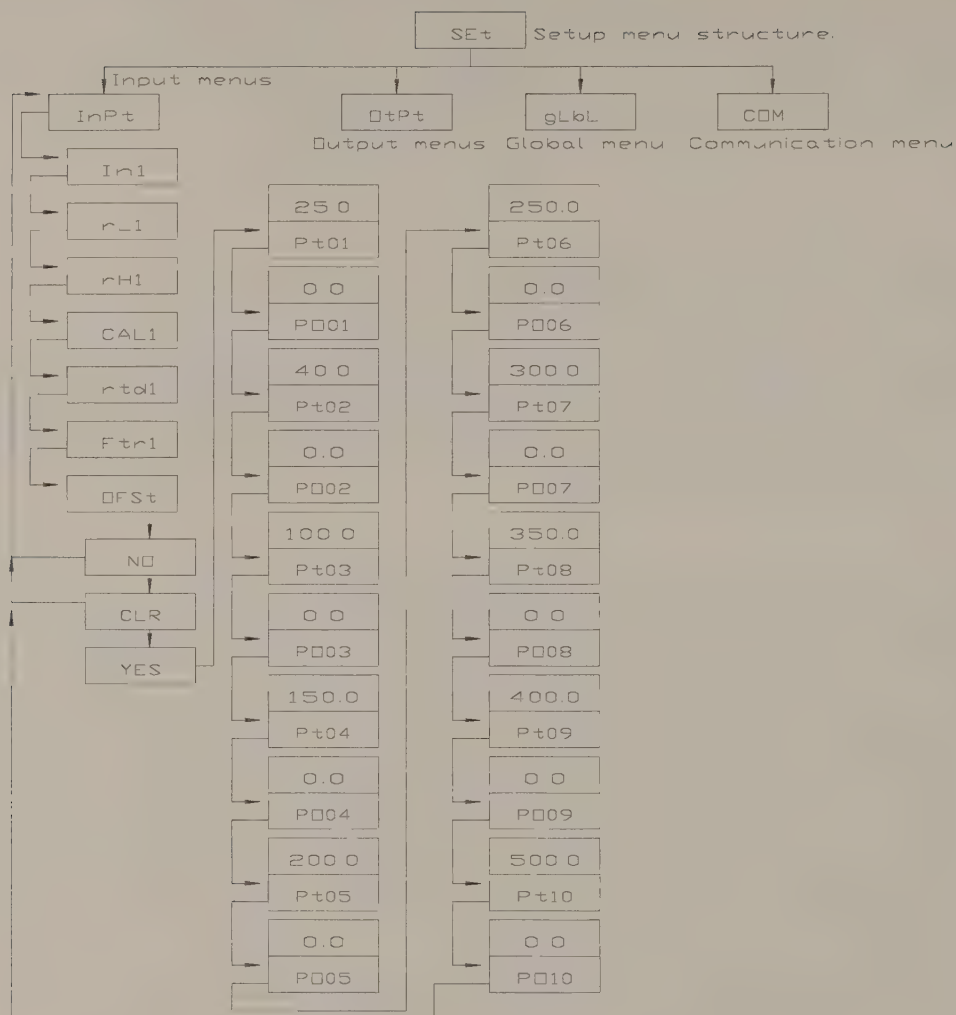


FIGURE 1. INPUT (SETUP) MENU WITH "OFFSET" PROGRAM DEFAULTS

Yes means custom offsets are active. Switch from No to yes restores custom offsets, allows user to enter custom offsets, and/or to edit existing offsets. Clr Clears all custom offsets to reestablish the defaults and places program back to Yes. Default values are shown in the Input (setup) menu illustration.

2.1 Point x temperature

Point 1 temperature

Upper display = '25.0'

Lower display = 'Pt01'

Default = '25.0'

Range = -60.0 to 499.0

2.2 Point x offset.

Point 1 offset.

Upper display = '0.0'

Lower display = 'PO01'

Default = '0.0' (0 offset of Pt value)

Range = -99.0 to 99.0

NOTE:

the temperature and offset prompt flow would be Pt01, PO01, Pt02, PO02, etc. The input value will be converted linearly between the nearest 2 points. All added parameters are addressable through serial communication. The 'OFSt' commands for invoking the program are: 0 = no, 1 = yes, 2 = clr. The setpoint and offset point commands are structured : Pt01 through Pt10 and PO01 through PO10. Refer Appendix A for data and communication rules.

3.0 PROCEDURE:

APPLYING CUSTOM CALIBRATION OFFSETS

Copy the Calibration work sheet (Part No. A1011468) found at the end of this procedure. It is a useful sheet for keeping track of necessary adjustments.

- STEP 1. Enter both controllers Input (setup) menus and select OFSt to CLr. Exit menus (depress DSPY MODE button once). This clears any previous entries and returns to the factory defaults of zero offsets.
- STEP 2. Select at least 5 setpoints other than room ambient and fill in the worksheet **Temp Setpoint** column then add 400 degrees for the last temp Setpoint if not already used.
- STEP 3. Operate system to each setpoint and allow to soak for five minutes.
- STEP 4. Record the values of the temp controllers and standard in the appropriate columns at each setpoint. Record the external standard's measurement (or average measurement) twice; Same value once for each controller.
- STEP 5. Return system to room temperature.
- STEP 6. For each controller setpoint subtract the controller reading from the external standard reading and record these values in the **DEVIATION** column. These values are the offsets that you will want to enter for each controller. Formulae:
External Standard - HEAT (COOL) CONTROLLER = DEVIATION

- STEP 7. Record the Temp Setpoints into the **Pt VALUE** column for each controller. Point 1 should be the lowest value. Do not worry if you have less than ten setpoints to enter.
- STEP 8. Record the determined offset values in the **PO VALUE** column next to the corresponding **Pt VALUE**
- STEP 9. Enter both controllers Input (setup) menus and select OFSt menus. It will read YES. Enter new setpoints Ptxx and offsets POxx using you worksheet.
- STEP 10. Exit menus (depress DSPY MODE button once). The new calibration offsets will be active.

The calibration then can be checked and further tightened up by reperforming the procedure eliminating STEP 2. and reusing the setpoints.

CALIBRATION WORK SHEET

Chuck style _____ Temperature Range _____
 System Configuration _____

Serial No. _____

Temp Setpoint	HEAT CONTROL	External Standard	DEVIATION		COOL CONTROL	External Standard	DEVIATION	NOTES
HEAT CONTROLLER CUSTOM OFFSETS					COOL CONTROLLER CUSTOM OFFSETS			
OFFSET POINT	Pt VALUE	PO VALUE			OFFSET POINT	Pt VALUE	PO VALUE	
1					1			
2					2			
3					3			
4					4			
5					5			
6					6			
7					7			
8					8			
9					9			
10					10			

Data Taken By: _____ Date: _____

CALIBRATION WORK SHEET

Chuck style _____ **Temperature Range** _____

System Configuration _____

Serial No. _____

Temp Setpoint HEAT External DEVIATION
 CONTROL Standard

COOL External DEVIATION NOTES
CONTROL Standard

HEAT CONTROLLER CUSTOM OFFSETS

OFFSET POINT	Pt VALUE	PO VALUE	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

COOL CONTROLLER CUSTOM OFFSETS

OFFSET POINT	Pt VALUE	PO VALUE	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Data taken by: _____ Date _____

H1000 Series Chuck Assembly Check Out Sheet

1. Measure continuity and isolation of RF / BNC connections.
 - a.) Center conductor to chuck surface ... _____
 - b.) Shield conductor to chuck shell / radiator ... _____
 - c.) Center conductor to shield conductor ... _____
2. Thermocouple temperature with chuck @ 100 degrees C. _____
200 degrees C. _____
3. Heating element resistance:
 - a.) @ ambient temperature. (DMM) ... _____
 - b.) @ 390 degrees C. (DMM) ... _____
4. Chuck assembly isolation:
 - a.) @ ambient temperature ... _____
 - b.) @ 390 degrees C ... _____
5. Measure capacitance of heating element to chuck surface.
 - a.) @ ambient temperature ... _____
 - b.) @ 390 degrees C ... _____
6. Measure isolation resistance of thermocouple from chuck surface.
 - a.) @ ambient temperature ... _____
 - b.) @ 390 degrees C ... _____
7. Measure capacitance of thermocouple to chuck surface.
 - a.) @ ambient temperature ... _____
 - b.) @ 390 degrees C ... _____
8. Measure isolation resistance of RTDs from chuck surface.
 - a.) @ ambient temperature ... RTD1 _____ RTD2 _____
 - b.) @ 390 degrees C ... RTD1 _____ RTD2 _____
9. Measure capacitance of RTDs to chuck surface.
 - a.) @ ambient temperature ... RTD1 _____ RTD2 _____
 - b.) @ 390 degrees C ... RTD1 _____ RTD2 _____
10. Verify proper operation of isolation relay.
 - a.) When connected to relay override assembly ... _____
 - b.) When connected to controller ... _____
11. Planarity of chuck in final assembly ... _____
12. Final appearance (comments) ... _____

Assembly # _____ Work order # _____

Test Technician: _____ Date: _____

Q.A. Representative: _____ Date: _____

H1000 Cool Module #2 Configuration and Test Procedure

Purpose:

This procedure is intended to provide a sequence of steps to guide the proper configuration and functional test of the A1010760 assembly (H1000 Series Cool Module #2). Fill out check sheet A1011214 as you progress through this test.

Equipment:

- a. SRV / Cool module test fixture.
- b. IBM compatible pc with an RS422 communications adapter and software.
- c. Cables: A1010607 - SRV power cable, or equivalent.
 A1010565 - Heat to cool module cable, or equivalent.
 A1007713 - Line cord, or equivalent.
 A1008947 - H1000-RS232 module to controller cable, or equivalent.

Reference Documents:

A1010760 - Assembly, Cool Module #2.
 A1009777 - Series 1000 Thermal Chuck Systems Operation Manual.
 Watlow Controls Series 988 User's Manual.

Procedure:

1.) With the test fixture OFF, connect the Cool Control Module to the test fixture and the computer communication adapter. Set all the switches on the test fixture to 'OFF'. Extract controller and insure "INPUT" dip switches are set for RTD operation: Switch 1 & 2 off; Switch 3 on. Reinsert the controller.

2.) Turn on the test fixture and set the controller parameters as follows (Depress and hold the UP and DOWN ARROW buttons for approximately 3 seconds to access the setup menus).

Note: InPt: In1 - rt.d; and GLbL: C_F - C parameters MUST be set prior to entering the remainder of the configuration settings.

a.) InPt: In1 - rt.d

b.) GLbL: C_F - C

c.) InPt: In1 - rt.d; rL1 - -2.0; rH1 - 399.0; CAL1 - 0.0; rtd1 - din; Ftr1 - 0

d.) OtPt: Ot1 - CL; HYS1 - 0.1 (When prompt is present); Ot2 - CL; HYS2 - 0.1; SP2c - dE; Ot3 - AL3n; AL3 - rAtE; A3Sd - HIGH;
 HYS3 - 0.1; LAt3 - nLA; SIL3 - OFF

e.) GLbL: C_F - C; FAIL - 0; Err - nLA; Ei1 - OFF; Anun - ON; LoP - -100; HiP - 0; AtSP - -90; rP - OFF

f.) COM: bAUd - 9600; dATA - 7o; Prot - FULL; Addr - 2; IntF - 422

h.) SYS: EiS - CLOS; A3LO - -55.5; A3HI - 555.5; AUt - OFF

i.) **PidA:** Pb1A - 4.0; rE1A - 0.20; rA1A - 0.05; Ct1A - 10.0; Pb2A - 0.0;

g.) **SP2** - -25

3.) Press the 'PURGE' switch on the module.

- The switch should latch 'ON'.
- The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should be 'ON'.

4.) Press the 'PURGE' switch again.

- The switch should release 'OFF'.
- The 'Purge Timer' l.e.d. and 'PURGE' switch lamp should be 'OFF'.

5.) Set 'SET TEMP' to 30 degrees and rotate the 'RTD INPUT' potentiometer until the controller temperature display reads ~ 50 degrees.

The 'ACTIVE' and 'Cool Valve' l.e.d.'s should be 'OFF'.

Place the 'EVENT 1' switch to the 'ON' position.

The 'ACTIVE' and 'Cool Valve' l.e.d.'s should be 'ON' (there may be a delay of up to 10 seconds before the 'Cool Valve' l.e.d. turns 'ON').

6.) Rotate the 'RTD INPUT' potentiometer counter clockwise until the temperature display reaches or is below the 'SET TEMP' (but not less than 20 degrees below the set temperature).

- The 'ACTIVE' and 'Cool Valve' l.e.d.'s should turn 'OFF' (there may be a delay of up to 10 seconds before the 'Cool Valve' l.e.d. turns 'OFF').

7.) Place the 'EVENT 1' switch to the 'OFF' position.

The 'Purge Timer' l.e.d. and 'PURGE' switch lamp on should switch 'ON' and remain 'ON' for a duration of 55 to 65 seconds.

8) Turn the test fixture off then back on

The 'Purge Timer' l.e.d. and 'PURGE' switch lamp on should switch 'ON' and remain 'ON' for a duration of 55 to 65 seconds.

9.) Rotate the 'RTD INPUT' potentiometer fully counter clockwise.

- The temperature display should contain " ---- ".
- The 'SET TEMP' window should display "0".

10.) Adjust the 'SET TEMP' to verify the minimum and maximum set temp points.

- Minimum 'SET TEMP' should be -2.0 degrees.
- Maximum 'SET TEMP' should be 399.0 degrees.

11.) Using PcTC or other communications software, verify the proper function of the module's RS422 communications by reading and setting the 'SET TEMP' (SP1).

12.) As a final step set the **PLOC**: LOC to 2. (Depress and hold the UP and DOWN ARROW buttons for approximately 6 seconds to access the factory menus)

Cool Module #2 Test - Check Out Sheet

Document # A1011214 Rev. A

Procedure:

Complete this check out sheet referencing the H1000 Cool Module #2 Configuration and Test Procedure (doc. #A1011213).

- 1.) Cool module connected to test fixture properly _____
- 2.) Controller configuration set as specified by the
cool module #2 configuration and test procedure. _____
- 3.) 'PURGE' switch latches on . _____
'PURGE' switch lamp lights. _____
- 4.) 'PURGE' switch latches off . _____
'PURGE' switch lamp extinguishes _____
- 5.) Verify proper EVENT 1 switch operation. _____
- 6.) Verify cooling control operation _____
- 7.) Verify that controller initiates purge when exiting cool mode and
'Purge Timer' operation and setting of 55 - 65 seconds. _____
- 8.) Verify that controller initiates "POWER ON PURGE". _____
- 9.) Verify open RTD failure mode _____
- 10.) Verify max. and min. 'SET TEMP' points max. _____
min. _____
- 11.) Verify proper RS422 communications. _____
- 12.) PLOC set to 2. _____

Work Order # _____

Test Technician: _____ Date: _____

NOTES

APPENDIX C
BILLS OF MATERIALS AND DRAWINGS

CURRENT REVISION: A

CURRENT ECN: DLH

DRAWING SIZE - 3D

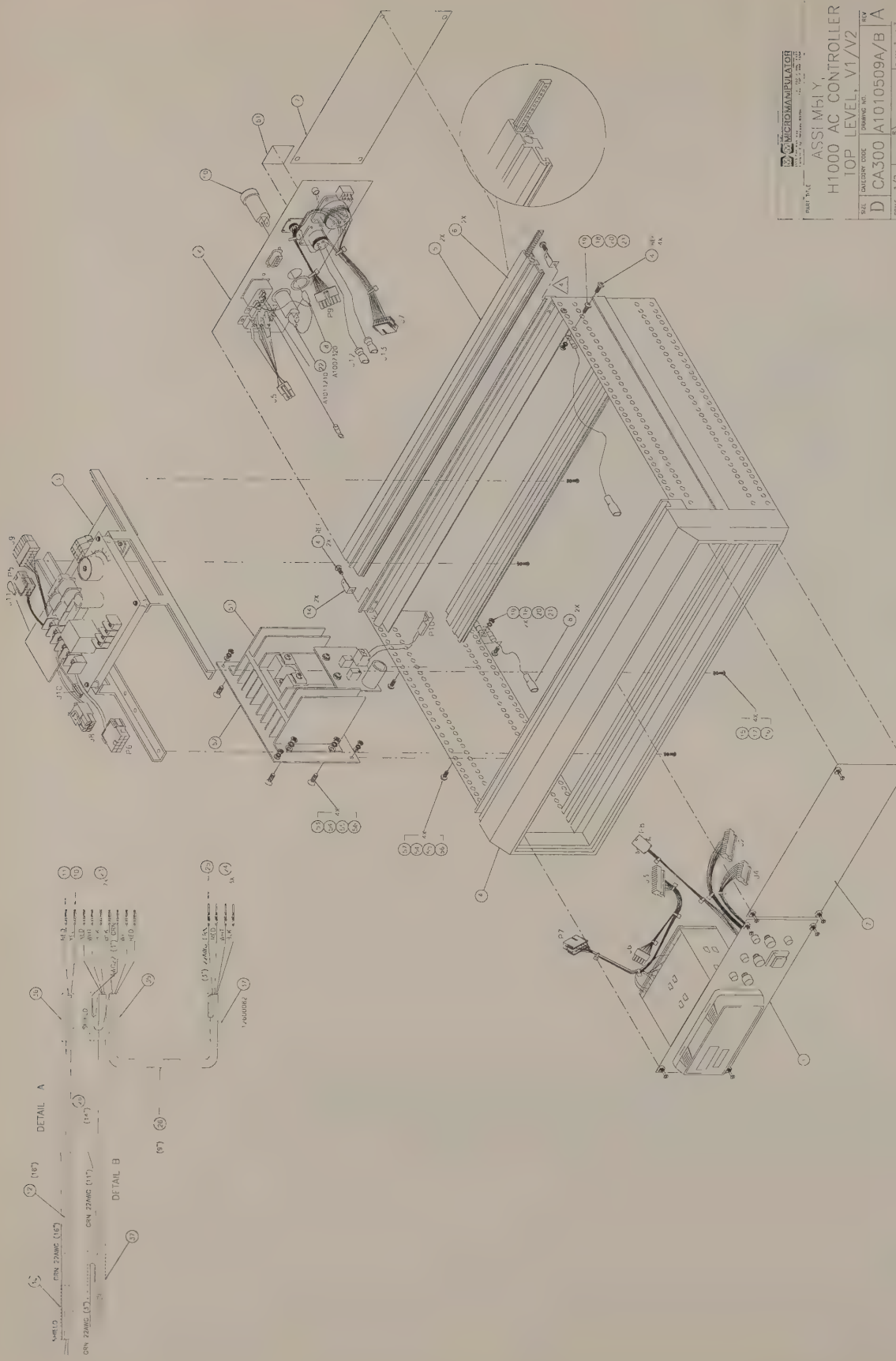
ITEM	PART NUMBER	DESCRIPTION	UM	REV	REQ'D
1	A1010966	CA200 ASSEMBLY, FRONT PANEL, H1000 CONTROLLERS	EA	A	1
2	A1010968	CA200 ASSEMBLY, REAR PANEL, H1000 CONTROLLER	EA	A	1
3	A1010967	CA200 ASSEMBLY, H1000 CONTROL CHASSIS	EA	A	1
4	A1009131	AE140 CHASSIS, 2/3 U SCHROFF CASE	EA	A	1
5	A1009132	AE140 RAILS, SCHROFF CARDPAC CASE HORIZONTAL	EA	A	2
6	A1009133	AE140 INSERT, SCHROFF THREADED INSERTS	EA	A	2
7	A1008446	CA200 ASSEMBLY, HEAT CONTROLLER BLANK PANEL	EA	A	2
8	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE, 0.032x0.250 TAB	EA	A	3
9	A1010461	AE600 WIRE, 18 AWG HOOK-UP, PVC GRN/YEL	FT	A	2.5
10	A1009828	AE210 CONTACT, TYPE K CHROMEGA (+), FEMALE	EA	A	1
11	A1009829	AE210 CONTACT, TYPE K ALOMEGA (-), FEMALE	EA	A	1
12	A1009827	OPX AE600 CABLE, SHIELDED TYPE K T/C 24 AWG	FT	A	1.333
13	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		3.083
14	A1008945	AE212 TAB, RIGHT ANGLE #8 MTG. .250 MALE	EA	A	2
15	12280061	OPX SCREW, 4-40 X 1/2 PHILLIPS DRIVE PAN HEAD SST	EA		4
16	12280091	OPX WASHER, #4 FLAT SS	EA		4
17	13128276	OPX WASHER, #4 INSIDE STAR	EA		4
18	12212022	AE212 LUG, #10 18-22 AWG INSULATION RING	EA		3
19	12280216	OPX AB200 SCREW, 10-32 X 3/8 PHIL DR PAN HD	EA		2
20	13128279	OPX WASHER, #10 INSIDE STAR	EA		2
21	13128205	OPX NUT, 10/32 HEX	EA		2
22	A10111210	AE212 TERMINAL, FEMALE, .250x.032 SLIP-ON, 14-16 AWG	EA	A	2
23	12210028	AE210 SOCKET, 20 GA. GOLD FLASH	EA		7
24	A1008032	AE210 CONTACT PIN, 24-26 AWG, F/CPC CONNECTOR	EA	A	3
25	12210076	AE210 CONTACT PIN, 20-24 AWG, F/CPC CONNECTOR	EA		1
26	A1008027	OPX AE600 CABLE, 4 COND, 24 AWG, SHIELDED BRAID	FT	A	1.917
27	6002-0194-0	OPX AE600 WIRE, 22 AWG WHITE & BROWN STRIPE	FT		0.25
28	6002-0189-0	OPX AE600 WIRE, 22 AWG WHITE & YELLOW STRIPE	FT		1.417
29	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		1.5

CURRENT REVISION: P13A

CURRENT ECN: DLH

DRAWING SIZE - 3D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
30	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		0.25
31	12600002	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BROWN	FT		0.5
32	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		1
33	A1005712	OPX WIRE, WHITE 16 AWG 26/30 STRAND 1000V	FT		0.833
34	A1005710	OPX WIRE, RED 16 AWG 26/30 STRAND 80 C 1000V	FT		1
35	12600083	OPX AE600 SLEEVING, 3/8 X 1 SHRINK	FT		0.125
36	12600081	OPX TUBING, 1/8 OD BLACK SHRINK	FT		0.25
37	12600082	OPX TUBING, 1/4 BLACK SHRINK	FT		0.25
38	A1008422	AE212 RECEPT., FASTON, .187 FEMALE FULLY INSULATED	EA	A	2
50	A1006510	AE275 CIRCUIT BREAKER 15 AMP, HEINEMAN KD1-15	EA		1
51	A1011244	CA200 ASSEMBLY, BURST FIRING SOLID STATE RELAY	EA	A	1
52	A1010759	DA050 PLATE, SSR HEATSINK MOUNTING	EA	B	1
53	13128171	OPX AB200 SCREW, 8-32 X 1/2 PHIL DR PAN HD	EA		4
54	12280199	OPX WASHER, #8 FLAT	EA		8
55	13128278	OPX WASHER, #8 INSIDE STAR	EA		8
56	13128204	OPX AB200 NUT, 8-32 HEX	EA		8
57	12280186	OPX SCREW, 8-32 X 3/8 PHILLIPS DRIVE FLAT HEAD	EA		4
58	12212034	OPX LUG, #10 14-15 AWG INSULATION RING	EA		2
61	A1010165	AG100 LABEL, CE MARK .875 INCH	EA	A	1
99	A1011417	AG100 CHECKOUT SHEET, H1000 AC/DC HEAT CONTROLLER	EA	A	1



PART NAME		ASSI MBLY.	
H1000 AC CONTROLLER		IOP LEVEL, V1/V2	
REV	DATE	REV	DATE
D	CA300	A	1010509A/B
SCALE	1/2	SCALE	1/2
SHEET 1 OF 3		SHEET 1 OF 3	

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ.D
1	A1009788	PSY PANEL, H1001 FRONT PANEL	EA	A	1
2	A1009144	AE140 SLEEVE FOR CAPTIVITY PANEL HARDWARE	EA	A	4
3	A1009145	AE140 COLLAR SCREW FOR CAPTIVITY PANEL HARDWARE	EA	A	4
4	A1009813	AE220 CONTROLLER, TMMCO MODEL DC ONLY W/COMMS	EA	A	1
5	12500035	AE500 SWITCH, 2PDT	EA		1
6	A1009854	AE500 LENS, GREEN TRANSPARENT SWITCH	EA	A	1
7	A1002147	AE245 LAMP, 110V OSHINO NEON(09-960.8)	EA		1
8	12245016	AE245 GREEN LED	EA		3
9	12240023	AE240 LENS/MOUNT, GREEN, T-1 3/4"	EA		3
10	12240007	AE240 CLIP, LED T.1.3/4" MOUNTING	EA		4
11	A1007127	AE240 LENS/MOUNT, LED YELLOW T-1 3/4	EA		1
12	A1007126	AE245 LED, YELLOW, T-1-3/4 CLEAR	EA		1
13	12500016	AE500 SWITCH DPDT MOMENTARY P-B W/WHITE CAP	EA		3
14	A1009855	AE240 BUTTON, BLACK PUSHBUTTON SWITCH	EA	A	3
15	A1001262	AE210 CONN., PLUG, 6-PIN MOLEX 15-31-1061	EA		1
16	A1001264	AE210 PIN, MALE (MOLEX 5025 SERIES) P/N 08-70-0043	EA		6
22	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		3.833
23	12600002	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BROWN	FT		1.917
24	12600003	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC RED	FT		2.167
25	12600004	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC ORANGE	FT		3.917
26	12600005	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC YELLOW	FT		2.75
27	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		2.583
28	12600007	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BLUE	FT		2.5
29	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		2.333
30	12600009	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREY	FT		0.667
31	12600010	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC WHITE	FT	A	1.583
32	6002-0189-0	OPX AE600 WIRE, 22 AWG WHITE & YELLOW STRIPE	FT		2.167
33	6002-0190-0	OPX AE600 WIRE, 22 AWG WHITE & RED STRIPE	FT		0.667
34	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		1.333
35	6002-0194-0	OPX AE600 WIRE, 22 AWG WHITE & BROWN STRIPE	FT		0.833
36	12600086	OPX TUBING, 3/4" O.D. BLACK SHRINK	FT	A	0.125
37	12210082	AE210 CONNECTOR, HOUSING, 8 POS., 22 AWG	EA		1
38	12210071	AE210 CONNECTOR, 12 POS HOUSING, 22 AWG	EA		2

CURRENT REVISION: A

CURRENT ECN: DLH

NO PENDING ENGINEERING CHANGES

DRAWING SIZE - D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ,D
39	12600040	OPX CABLE TIE, WHITE NYLON 4"	EA		10
40	6002-0196-0	OPX WIRE, 22 WHT/BLK PRE-TINNED,ALPHA A3155	EA		1.333
41	A1010503	OPX AE600 CABLE, 6 COND., 24 AWG SHIELDED	FT	A	0.583
42	A1004420	AE210 CONNECTOR, HOUSING, MALE, 10 POS.	EA	A	1
43	A1004421	AE210 CONNECTOR, CONTACT, FEMALE SOCKET,	EA	A	10
44	A1011149	AE210 CONN,HOUSING,FEMALE,12 POS,MOLEX MINI FIT JR	EA	A	1
45	A1004423	AE210 CONNECTOR, CONTACT, MALE PIN, 22-28AWG	EA	B	11
46	1511-0111-0	AE150 CP, CERAMIC 50V 20PC 100NF,	EA		2
47	12600107	OPX SLEEVEING, 20GA.	FT		0.25

		10000 CONTROLLERS ASS'Y MBLY, FRONT PANEL, REV.	
DATE: 10/1/74 DESIGNED BY: J. L. HARRIS DRAWN BY: J. L. HARRIS	SIZE: D CATEGORY: CA200 DRAWING NO.: A1010966	SHEET: 1 OF: 1	PROJECT: 10000-1A

CURRENT REVISION: A

NO PENDING ENGINEERING CHANGES

DRAWING SIZE - 2C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009789	PSY PANEL, HEAT MODULE REAR	EA	A	1
2	A1009144	AE140 SLEEVE FOR CAPTIVITY PANEL HARDWARE	EA	A	4
3	A1009145	AE140 COLLAR SCREW FOR CAPTIVITY PANEL HARDWARE	EA	A	4
4	12240007	AE240 CLIP, LED T.1.3/4" MOUNTING	EA		1
5	12245014	AE245 LED, RED, T-1-3/4" CLEAR	EA		1
6	12240021	AE240 LENS/MOUNT, RED, T-1 3/4"	EA		1
7	12500016	AE500 SWITCH DPDT MOMENTARY P-B W/WHITE CAP	EA		1
8	A1009855	AE240 BUTTON, BLACK PUSHBUTTON SWITCH	EA	A	1
10	A1008422	AE212 RECEPT., FASTON, .187 FEMALE FULLY INSULATED	EA	A	2
11	A1004657	AE240 RECEPTACLE, AC POWER, 250V, 15 AMP	EA		1
12	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		0.8333
13	12210086	AE210 RECEPTACLE, 17-16 SQUARE FLANGED (16 POSN.)	EA	A	1
14	12210076	AE210 CONTACT PIN, 20-24 AWG, F/CPC CONNECTOR	EA		12
15	12210075	AE210 CONTACT, PIN, 16-18 AWG, F/CPC CONNECTOR	EA		2
16	12210034	AE210 RECEPTACLE-VIKING, TFR07-101-P	EA		1
17	12210036	AE210 CONTACT, MALE-VIKING, TP100-AU	EA		7
18	12210072	AE210 RECEPTACLE, 4 POSITION SQUARE FLANGED	EA		1
19	A1007543	AE210 CONN, 9 POS, D-SUB, PLUG W/O SOCKETS	EA	A	1
20	2100-0131-0	AE210 HARDWARE, CONNECTOR MOUNTING, D SERIES	EA		2
21	12275036	AE275 CIRCUIT BREAKER, KD1-2.5	EA		1
22	5100-0006-0	AE500 SWITCH, 115-230 CHANGEOVER SWITCHCRAFT	EA		2
26	12600002	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BROWN	FT		0.667
27	12600003	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC RED	FT		1.75
28	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		0.917
29	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		1.25
30	12600009	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREY	FT		2.5
31	12600010	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC WHITE	FT	A	1.167
32	6002-0189-0	OPX AE600 WIRE, 22 AWG WHITE & YELLOW STRIPE	FT		0.75
33	6002-0190-0	OPX AE600 WIRE, 22 AWG WHITE & RED STRIPE	FT		0.25

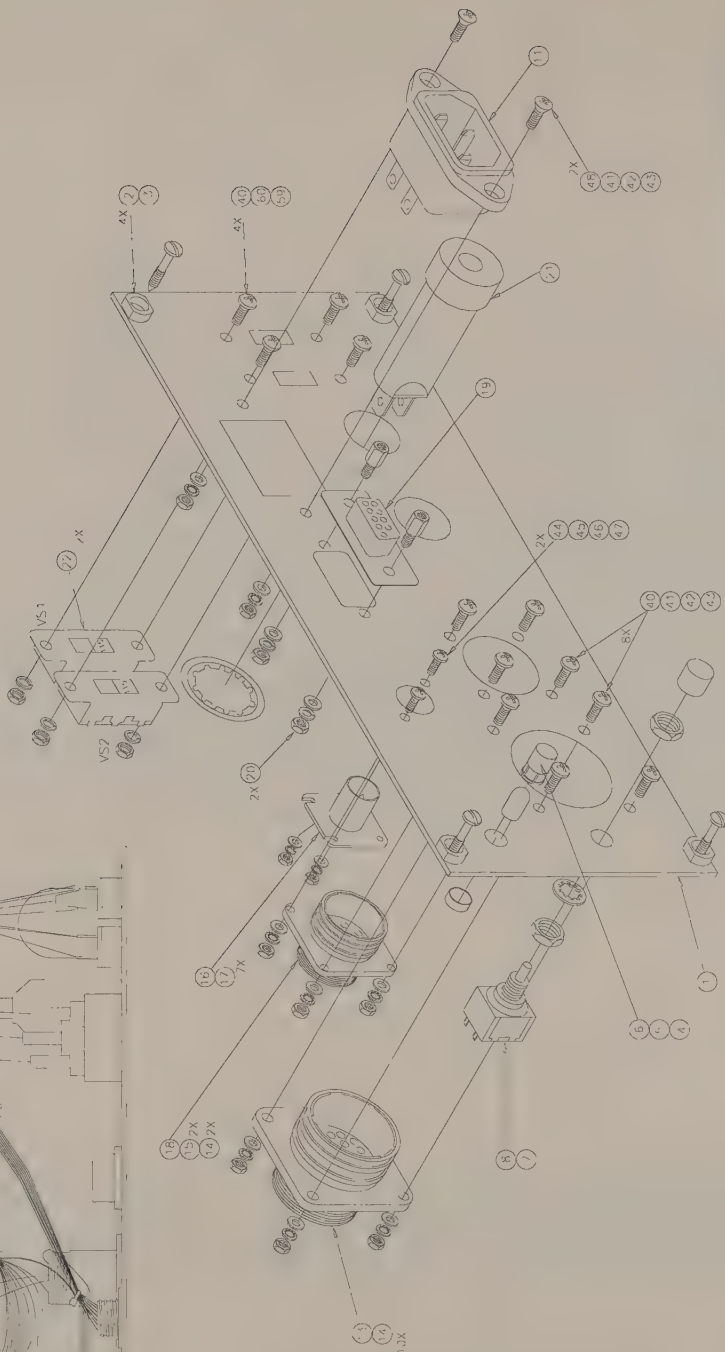
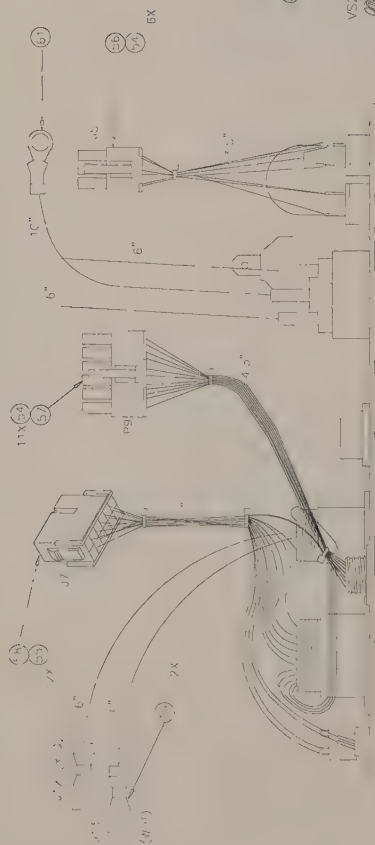
CURRENT REVISION: A

CURRENT ECN: DLH

NO PENDING ENGINEERING CHANGES

DRAWING SIZE - 2C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
35	A1005710	OPX WIRE, RED 16 AWG 26/30 STRAND 80 C 1000V	FT		1
36	A1005712	OPX WIRE, WHITE 16 AWG 26/30 STRAND 1000V	FT		1
38	12600004	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC ORANGE	FT		1
39	6002-0196-0	OPX WIRE, 22 WHT/BLK PRE-TINNED,ALPHA A3155	EA		0.833
40	12280059	OPX SCREW, 4-40 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		12
41	12280091	OPX WASHER, #4 FLAT SS	EA		10
42	13128276	OPX WASHER, #4 INSIDE STAR	EA		10
43	13128201	OPX NUT, 4-40 HEX	EA		10
44	12280005	OPX SCREW, #2-56 X 3/8 PH PHIL SS	EA		2
45	13128250	OPX AB200 WASHER, #2 FLAT	EA		2
46	12280039	OPX WASHER, #2 SPLIT LOCK, SS	EA		2
47	12280041	OPX NUT, #2-56 SS	EA		2
48	12280078	OPX SCREW, 4-40 X 3/8 FLAT PHIL SS	EA		2
49	12600080	OPX AE600 TUBING, 3/32 SHRINK	FT		0.25
50	12600081	OPX TUBING, 1/8 OD BLACK SHRINK	FT		0.25
51	12600087	OPX TUBING, 3/16 BLACK SHRINK	FT		0.25
52	12600082	OPX TUBING, 1/4 BLACK SHRINK	FT		0.25
53	A1010461	AE600 WIRE, 18 AWG HOOK-UP, PVC GRN/YEL	FT	A	0.8333
54	A1004421	AE210 CONNECTOR, CONTACT, FEMALE SOCKET,	EA	A	17
55	A1004423	AE210 CONNECTOR, CONTACT, MALE PIN, 22-28AWG	EA	B	12
56	A1011146	AE210 CONN.,HOUSING,MALE;6 POS,MOLEX MINI FIT JR.	EA	A	1
57	A1011148	AE210 CONNECTOR, HOUSING, MALE, 12 POS,MINI FIT JR	EA	A	1
58	A1011149	AE210 CONN,HOUSING,FEMALE,12 POS,MOLEX MINI FIT JR	EA	A	1
59	12280090	OPX NUT, 4-40 RADIO SIZE SST	EA		4
60	13128284	OPX WASHER, #4 SPLIT LOCK	EA		4
61	12212022	AE212 LUG, #10 18-22 AWG INSULATION RING	EA		1
62	A1004168	OPX WRAP, BLACK SPIRAL, 3/16 O.D.	FT		2



MICROMANIPULATOR
 Model 1000
 Drawing No. 1000-1A

PART TITLE

ASSEMBLY, REAR PANEL,
 H1000 CONTROLLER

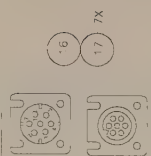
SIZE CATEGORY CODE DRAWING NO. REV.

C CA200 A1010968 A

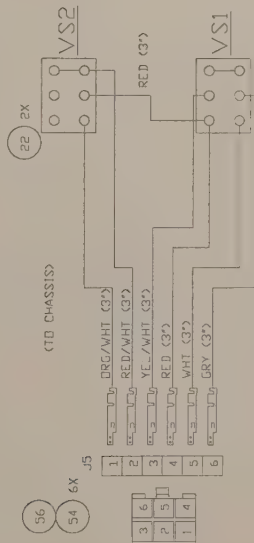
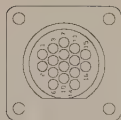
SCALE 1/1 FILENAME PDS0011 10968-1A SHEET 1 OF 2

(1D FRONT PANEL)

Computer Interface



Interface



(1D CHASSIS)



CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

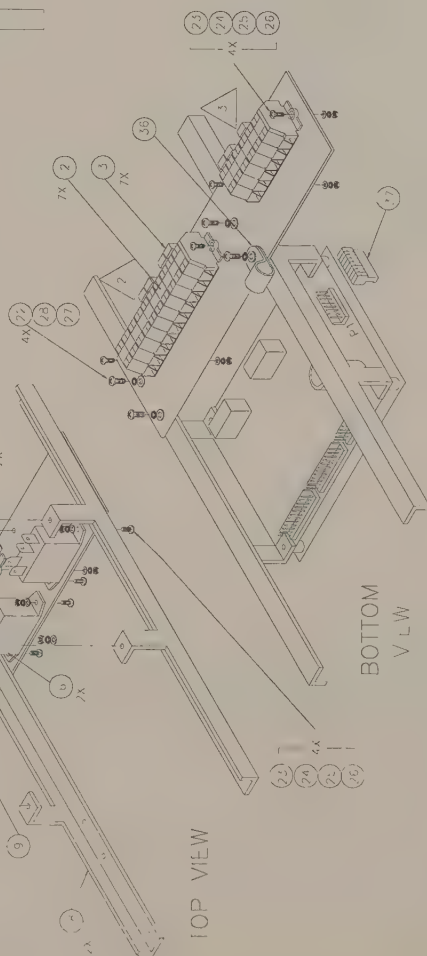
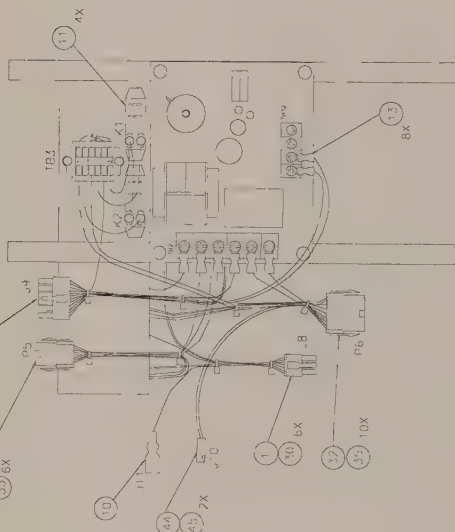
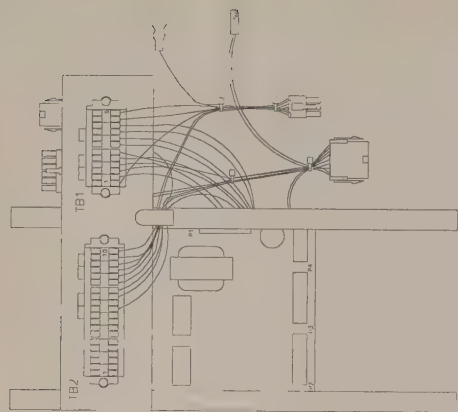
DRAWING SIZE - 2C

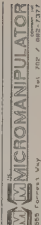
ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1001261	AE210 CONN., RECEPTACLE, 6-PIN MOLEX 15-31-1062	EA		1
2	A1009487	AE210 TERMINAL STRIP, CAGE CLAMP 3-CKT'S OF 4 COND	EA	A	7
3	A1009488	AE210 JUMPER BAR, COMB TYPE, 2-POLE	EA	A	7
4	A1009122	AE220 TEMPERATURE LIMITER, OPEN BOARD	EA	A	1
5	A1009794	CA200 ASSY., POWER ON RESET CIRCUIT BOARD	EA	A	1
6	A1009797	AE400 RELAY, 16 AMP 12V COIL FORM 1A	EA	A	2
7	12480015	AE480 DIODE, 1N914 SIGNAL	EA		2
8	A1009851	DA050 BRACKET, HEAT MODULE #1 SUPPORT	EA	A	2
9	A1009852	PSY BRACKET, HEAT MODULE #2 SUPPORT	EA	A	1
10	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE, 0.032x0.250 TAB	EA	A	1
11	A1011211	AE212 TERMINAL, FEMALE, .187 X .02 SLIP-ON, 22-18 AWG	EA	A	4
12	12600010	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC WHITE	FT	A	3.5
13	A1004156	AE212 TERMINAL, SNAP SPADE, #6 22-18AWG, INS.	EA	A	8
14	12600003	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC RED	FT		3.667
15	12600005	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC YELLOW	FT		1.916
16	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		2.917
17	12600007	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BLUE	FT		0.583
18	12600009	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREY	FT		4
19	6002-0190-0	OPX AE600 WIRE, 22 AWG WHITE & RED STRIPE	FT		1
20	12600107	OPX SLEEVING, 20GA.	FT		0.125
21	12280118	OPX SCREW, 6-32 X 3/4 PHILLIPS DRIVE, PAN HEAD	EA		4
22	12280113	OPX SCREW, 6-32 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		4
23	12280059	OPX SCREW, 4-40 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		10
24	12280091	OPX WASHER, #4 FLAT SS	EA		10
25	13128276	OPX WASHER, #4 INSIDE STAR	EA		10
26	13128201	OPX NUT, 4-40 HEX	EA		10
27	12280145	OPX WASHER, #6 FLAT	EA		8
28	13128277	OPX WASHER, #6 INSIDE STAR	EA		8
29	6002-0196-0	OPX WIRE, 22 WHT/BLK PRE-TINNED, ALPHA A3155	EA		1.167
30	A1001263	AE210 PINS, FEMALE MOLEX 5025 SERIES (08-70-0042)	EA		6
31	A1011147	AE210 CONNECTOR, HOUSING, FEMALE, 6 POSITION	EA	A	1
32	A1004422	AE210 CONNECTOR, HOUSING, FEMALE, 10 POS	EA	A	1
33	A1011148	AE210 CONNECTOR, HOUSING, MALE, 12 POS, MINI FIT JR	EA	A	1

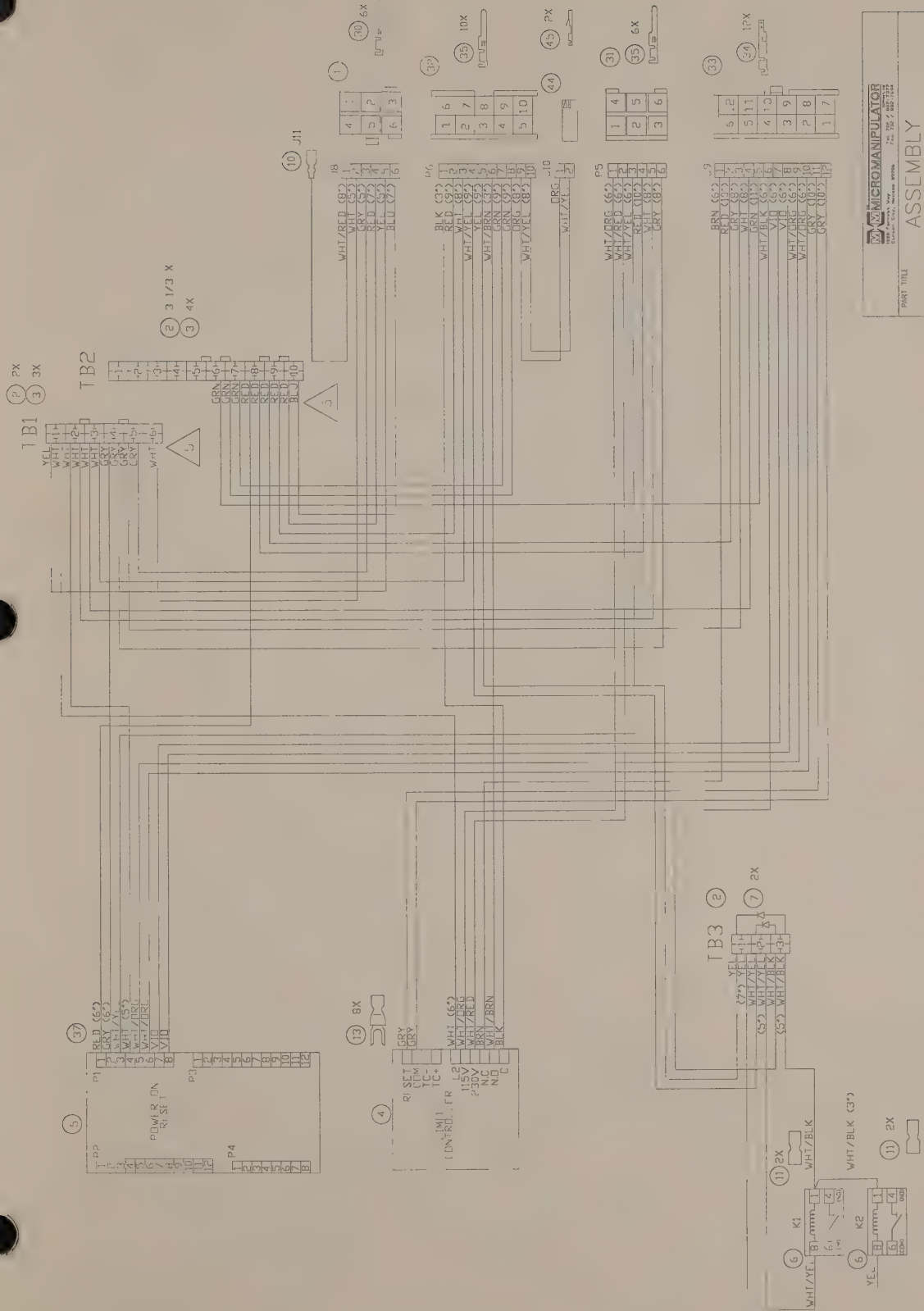
CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - 2C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
34	A1004421	AE210 CONNECTOR, CONTACT, FEMALE SOCKET,	EA	A	12
35	A1004423	AE210 CONNECTOR, CONTACT, MALE PIN, 22-28AWG	EA	B	16
36	12280274	AE280 CLAMP, 3/8 DIA. CABLE	EA		1
37	12210082	AE210 CONNECTOR, HOUSING, 8 POS., 22 AWG	EA		1
38	6002-0194-0	OPX AE600 WIRE, 22 AWG WHITE & BROWN STRIPE	FT		0.25
39	6002-0189-0	OPX AE600 WIRE, 22 AWG WHITE & YELLOW STRIPE	FT		2.333
40	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		1.5
41	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		0.25
42	12600002	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BROWN	FT		0.5
43	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		1
44	A1004003	AE210 HOUSING, 2 CKT G VERSION W/LATCH MOLEX	EA		1
45	2121-0074-0	AE210 RECEPT., MINI PV .025 SQ MOLEX 16-02-0102	EA		2
46	12600004	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC ORANGE	FT		0.667



 MICROMANIPULATOR 1000 GARDEN WAY FARMINGDALE, N.Y. 11737 (516) 754-1000		ASSEMBLY, H1000 CONTROL CHASSIS		REV.	
PART TITLE		CATEGORY CODE	DRAWING NO.	REV.	
C		CA200	A1010967	A	
SCALE		1/2	FILENAME	SHEET 1 OF 2	

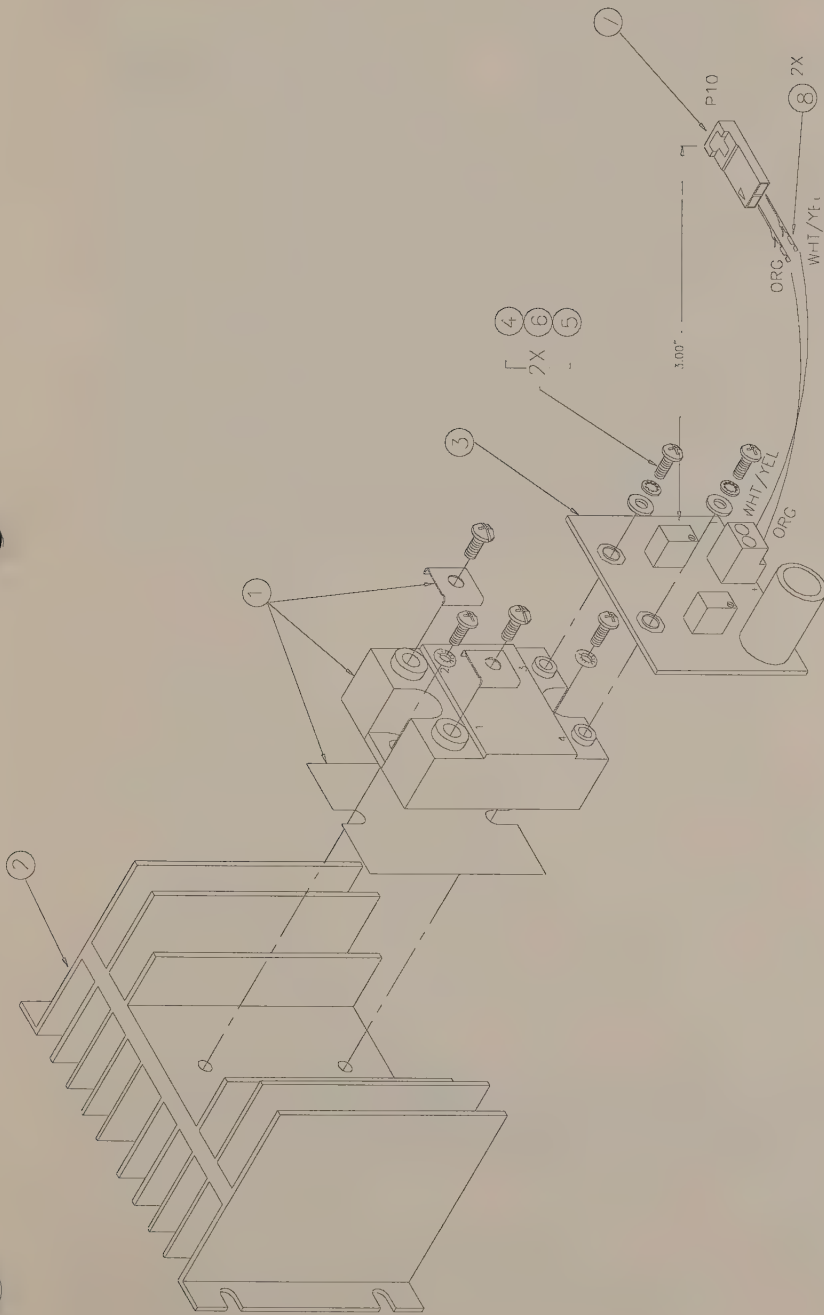


MICROMANIPULATOR 1000 CONTROL CHASSIS (WIRING DIAGRAM)	
PART TITLE	ASSEMBLY CONTROL CHASSIS (WIRING DIAGRAM)
REV	REV 1
SYN	CATEGORY CODE TRACKING NO
C	CA200 A1010967
SCALE: NONE	DISK #1 EXPRESSION
FILENAME: 10967-2A	SHEET 2 OF 2

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - A

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009120	AE487 RELAY, SOLID STATE	EA	A	1
2	A1009121	AE260 HEAT SINK FOR 25A SSR	EA	A	1
3	A1010508	AE170 CARD, BURST FIRING CONTROL SBL-5385	EA	A	1
4	12280118	OPX SCREW, 6-32 X 3/4 PHILLIPS DRIVE, PAN HEAD	EA		2
5	12280145	OPX WASHER, #6 FLAT	EA		2
6	13128277	OPX WASHER, #6 INSIDE STAR	EA		2
7	A1004001	AE210 CONNECTOR, 2 CKT WIRE TO WIRE FEMALE	EA		1
8	A1004002	AE210 TERMINAL, MALE 70021 SERIES 22-24 GAGE	EA		2
9	12600004	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC ORANGE	FT		0.25
10	6002-0189-0	OPX AE600 WIRE, 22 AWG WHITE & YELLOW STRIPE	FT		0.25



MICROMANIPULATOR 1535 General Way TOLSON, MD 21156 TEL: 410-732-1234 FAX: 410-732-1234				ASSEMBLY, BURST F RING SOLID STATE RELAY			
PART TITLE		DRAWING NO.		REV		SHEET	
A		CA200		A1011244		1	
SCALE		1/2		1 OF 1		1	

CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

CURRENT ECN: DLH

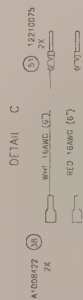
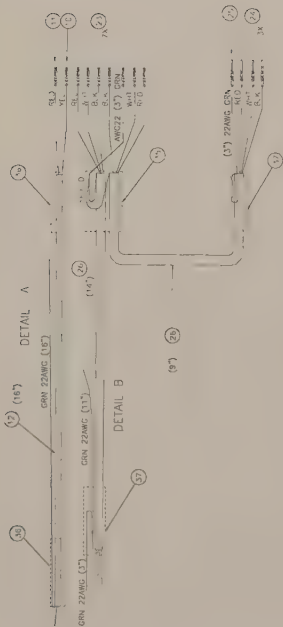
DRAWING SIZE - 3D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010966	CA200 ASSEMBLY, FRONT PANEL, H1000 CONTROLLERS	EA	A	1
2	A1010968	CA200 ASSEMBLY, REAR PANEL, H1000 CONTROLLER	EA	A	1
3	A1010967	CA200 ASSEMBLY, H1000 CONTROL CHASSIS	EA	A	1
4	A1009131	AE140 CHASSIS, 2/3 U SCHROFF CASE	EA	A	1
5	A1009132	AE140 RAILS, SCHROFF CARDPAC CASE HORIZONTAL	EA	A	2
6	A1009133	AE140 INSERT, SCHROFF THREADED INSERTS	EA	A	2
7	A1008446	CA200 ASSEMBLY, HEAT CONTROLLER BLANK PANEL	EA	A	2
8	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE, 0.032x0.250 TAB	EA	A	3
9	A1010461	AE600 WIRE, 18 AWG HOOK-UP, PVC GRN/YEL	FT	A	2.5
10	A1009828	AE210 CONTACT, TYPE K CHROME (G), FEMALE	EA	A	1
11	A1009829	AE210 CONTACT, TYPE K ALUMINA (G), FEMALE	EA	A	1
12	A1009827	OPX AE600 CABLE, SHIELDED TYPE K T/C 24 AWG	FT	A	1.333
13	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		3.083
14	A1008945	AE212 TAB, RIGHT ANGLE #8 MTG. .250 MALE	EA	A	2
15	12280061	OPX SCREW, 4-40 X 1/2 PHILLIPS DRIVE PAN HEAD SST	EA		4
16	12280091	OPX WASHER, #4 FLAT SS	EA		4
17	13128276	OPX WASHER, #4 INSIDE STAR	EA		4
18	12212022	AE212 LUG, #10 18-22 AWG INSULATION RING	EA		3
19	12280216	OPX AB200 SCREW, 10-32 X 3/8 PHIL DR PAN HD	EA		2
20	13128279	OPX WASHER, #10 INSIDE STAR	EA		2
21	13128205	OPX NUT, 10/32 HEX	EA		2
22	A1011210	AE212 TERMINAL, FEMALE, .250x.032 SLIP-ON, 14-16 AWG	EA	A	2
23	12210028	AE210 SOCKET, 20 GA. GOLD FLASH	EA		7
24	A1008032	AE210 CONTACT PIN, 24-26 AWG, F/CPC CONNECTOR	EA	A	3
25	12210076	AE210 CONTACT PIN, 20-24 AWG, F/CPC CONNECTOR	EA		1
26	A1008027	OPX AE600 CABLE, 4 COND, 24 AWG, SHIELDED BRAID	EA		1.917
27	6002-0194-0	OPX AE600 WIRE, 22 AWG WHITE & BROWN STRIPE	FT	A	0.25
28	6002-0189-0	OPX AE600 WIRE, 22 AWG WHITE & YELLOW STRIPE	FT		1.417
29	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		1.5

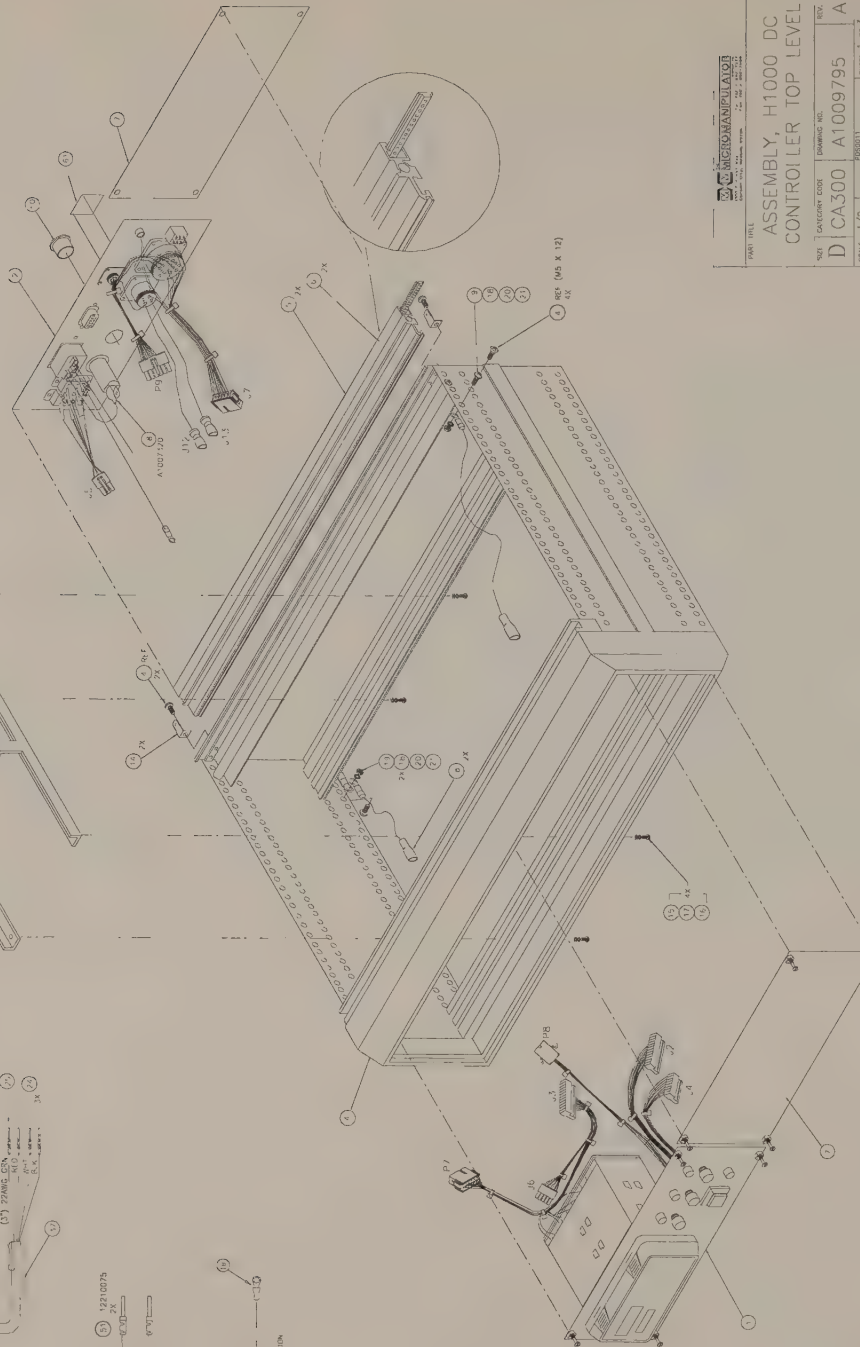
CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - 3D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
30	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		0.25
31	12600002	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BROWN	FT		0.5
32	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		1
33	A1005712	OPX WIRE, WHITE 16 AWG 26/30 STRAND 1000V	FT		0.833
34	A1005710	OPX WIRE, RED 16 AWG 26/30 STRAND 80 C 1000V	FT		1
35	12600083	OPX AE600 SLEEVING, 3/8 X 1 SHRINK	FT		0.125
36	12600081	OPX TUBING, 1/8 OD BLACK SHRINK	FT		0.25
37	12600082	OPX TUBING, 1/4 BLACK SHRINK	FT		0.25
38	A1008422	AE212 RECEPT., FASTON, .187 FEMALE FULLY INSULATED	EA	A	2
50	A1002279	OPX AE240 PLUG, PLATEN, BLACK, .625 DIA X .328 DP	EA		1
51	12210075	AE210 CONTACT, PIN, 16-18 AWG, F/CPC CONNECTOR	EA		2
61	A1010165	AG100 LABEL, CE MARK .875 INCH	EA		A
99	A1011417	AG100 CHECKOUT SHEET, H1000 AC/DC HEAT CONTROLLER	EA	A	1



LOCAL COVER TO CHASSIS GROUND CONNECTION
* TWO REQUIRED *



PART TITLE	ASSEMBLY, H1000 DC CONTROLLER TOP LEVEL
REV.	REV.
DATE CODE	DICA300 A1009795
SCALE	1/2
SHEET 1 OF 3	

CURRENT REVISION: A CURRENT ECN: DLH

NO PENDING ENGINEERING CHANGES

DRAWING SIZE - D2C

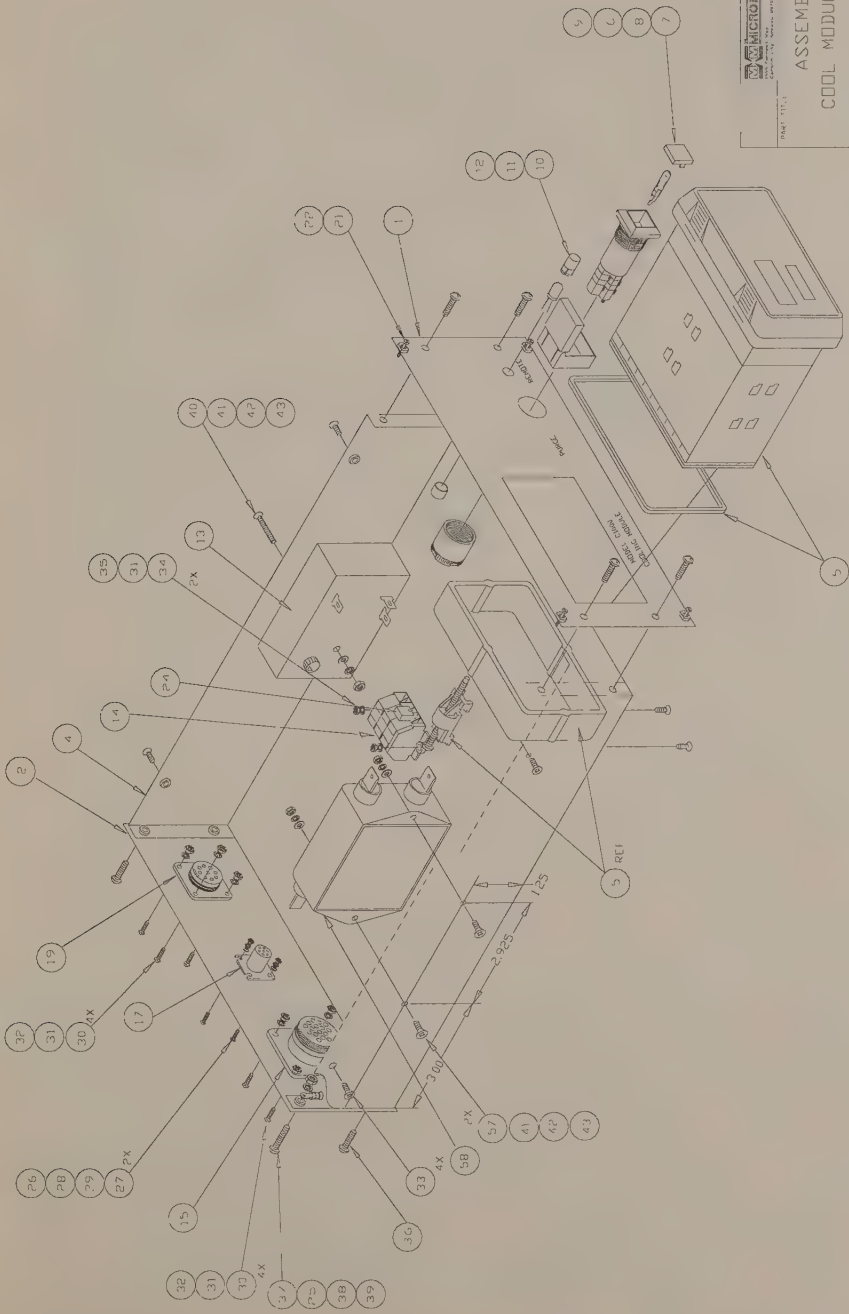
ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009787	DA075 PANEL, COOLING MODULE FRONT	EA	A	1
2	A1009791	PSY PANEL, COOL MODULE REAR	EA	A	1
3	A1009844	PSY BOX, 12.35 X 8.40	EA	A	1
4	A1009845	AA050 BOX, BOTTOM	EA	A	1
5	A1009813	AE220 CONTROLLER, TMMCO MODEL DC ONLY W/COMMS	EA	A	1
6	12500035	AE500 SWITCH, 2PDT	EA		1
7	A1009854	AE500 LENS, GREEN TRANSPARENT SWITCH	EA	A	1
8	A1002147	AE245 LAMP, 110V OSHINO NEON(09-960.8)	EA		1
9	A1006413	AE500 SWITCH, COVER PROTECTIVE, EAO SERIES 01 SQ.	EA	A	1
10	A1007127	AE240 LENS/MOUNT, LED YELLOW T-1 3/4	EA		1
11	A1007126	AE245 LED, YELLOW, T-1-3/4 CLEAR	EA		1
12	12240007	AE240 CLIP, LED T.I.3/4" MOUNTING	EA		1
13	A1009798	AE400 TIMER, INTERVAL 1 TO 100 SEC., ONBOARD ADJUST	EA	A	1
14	A1009487	AE210 TERMINAL STRIP, CAGE CLAMP 3-CKT'S OF 4 COND	EA	A	1
15	12210086	AE210 RECEPTACLE, 17-16 SQUARE FLANGED (16 POSN.)	EA	A	1
16	12210076	AE210 CONTACT PIN, 20-24 AWG, F/CPC CONNECTOR	EA		9
17	12210034	AE210 RECEPTACLE-VIKING, TFR07-101-P	EA		1
18	12210036	AE210 CONTACT, MALE-VIKING, TP100-AU	EA		5
19	12210030	AE210 RECEPTACLE, SQ. FLANGED, 9 PIN	EA		1
20	12210031	AE210 AE212 PIN, 20 AWG GOLD FLASH	EA		5
21	A1009145	AE140 COLLAR SCREW FOR CAPTIVITY PANEL HARDWARE	EA	A	4
22	A1009144	AE140 SLEEVE FOR CAPTIVITY PANEL HARDWARE	EA	A	4
23	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE,0.032x0.250 TAB	EA	A	8
24	A1009488	AE210 JUMPER BAR, COMB TYPE, 2-POLE	EA	A	1
25	12212018	AE212 RING, #6, 22-18 INSUL	EA		3
26	12280005	OPX SCREW, #2-56 X 3/8 PH PHIL SS	EA		2
27	13128200	OPX NUT, 2/56 HEX	EA		2
28	13128250	OPX AB200 WASHER, #2 FLAT	EA		2
29	13128275	OPX AB200 WASHER, #2 INSIDE STAR	EA		2

CURRENT REVISION: A

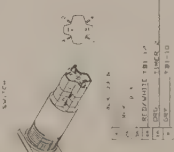
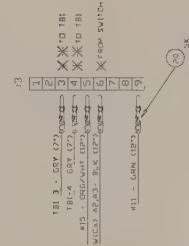
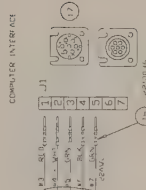
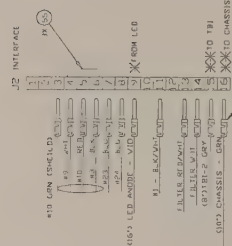
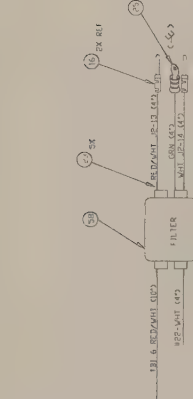
CURRENT ECN: DLH

DRAWING SIZE - D2C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
30	12280059	OPX SCREW, 4-40 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		8
31	13128276	OPX WASHER, #4 INSIDE STAR	EA		10
32	13128201	OPX NUT, 4-40 HEX	EA		8
36	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		7
37	12280115	OPX SCREW, 6-32 X 1/2 PAN PLPS SS	EA		1
38	13128277	OPX WASHER, #6 INSIDE STAR	EA		1
39	12280152	OPX NUT, 6-32 RADIO SIZE SST	EA		1
40	13128189	OPX SCREW, 8-32 X 1-1/2 PHILLIPS DRIVE FLAT HEAD	EA		1
41	12280199	OPX WASHER, #8 FLAT	EA		3
42	13128278	OPX WASHER, #8 INSIDE STAR	EA		3
43	13128204	OPX AB200 NUT, 8-32 HEX	EA		3
44	A1008027	OPX AE600 CABLE, 4 COND, 24 AWG, SHIELDED BRAID	FT	A	2.5
45	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		2.5
46	12600007	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BLUE	FT		2.5
47	6002-0196-0	OPX WIRE, 22 WHT/BLK PRE-TINNED, ALPHA A3155	EA		2.5
48	6002-0190-0	OPX AE600 WIRE, 22 AWG WHITE & RED STRIPE	FT		2.5
49	12600010	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC WHITE	FT	A	2.5
50	12600009	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREY	FT		2.5
51	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		2.5
52	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		2.5
53	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		3
54	12600003	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC RED	FT		2.5
55	A1008032	AE210 CONTACT PIN, 24-26 AWG, F/CPC CONNECTOR	EA	A	3
56	A1011021	AG100 SHEET, COOL MODULE #1 TEST - CHECK OUT	EA	A	1
57	12280186	OPX SCREW, 8-32 X 3/8 PHILLIPS DRIVE FLAT HEAD	EA		2
58	A1009853	AE270 FILTER, RF1 120/240V 5A	EA	A	1



		ASSEMBLY, COOL MODULE No.1	
37H	CA300	51V	B
37H	CA300	51V	B
37H	CA300	51V	B

[illegible]

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

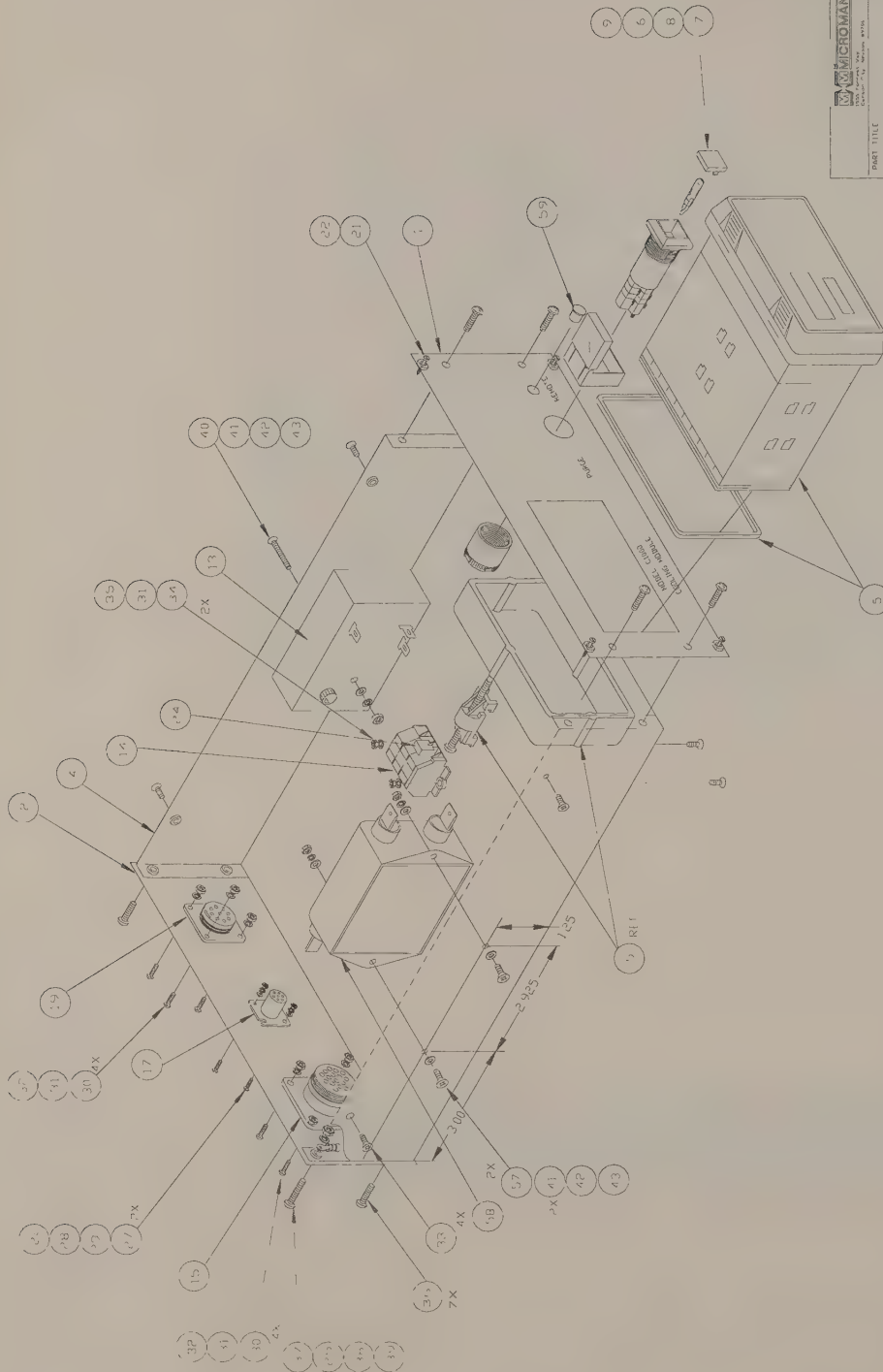
DRAWING SIZE - D2C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009787	DA075 PANEL, COOLING MODULE FRONT	EA	A	1
2	A1009791	PSY PANEL, COOL MODULE REAR	EA	A	1
3	A1009844	PSY BOX, 12.35 X 8.40	EA	A	1
4	A1009845	AA050 BOX, BOTTOM	EA	A	1
5	A1011264	AE220 CONTROLLER, TMMCo MODEL 0 DEGREE W/COMMS	EA		1
6	12500035	AE500 SWITCH, 2PDT	EA		1
7	A1009854	AE500 LENS, GREEN TRANSPARENT SWITCH	EA	A	1
8	A1002147	AE245 LAMP, 110V OSHINO NEON(09-960.8)	EA		1
9	A1006413	AE500 SWITCH, COVER PROTECTIVE, EAO SERIES 01 SQ.	EA	A	1
13	A1009798	AE400 TIMER, INTERVAL 1 TO 100 SEC., ONBOARD ADJUST	EA	A	1
14	A1009487	AE210 TERMINAL STRIP, CAGE CLAMP 3-CKT'S OF 4 COND	EA	A	1
15	12210086	AE210 RECEPTACLE, 17-16 SQUARE FLANGED (16 POSN.)	EA	A	1
16	12210076	AE210 CONTACT PIN, 20-24 AWG, F/CPC CONNECTOR	EA		7
17	12210034	AE210 RECEPTACLE-VIKING, TFR07-101-P	EA		1
18	12210036	AE210 CONTACT, MALE-VIKING, TP100-AU	EA		5
19	12210030	AE210 RECEPTACLE, SQ. FLANGED, 9 PIN	EA		1
20	12210031	AE210 AE212 PIN, 20 AWG GOLD FLASH	EA		5
21	A1009145	AE140 COLLAR SCREW FOR CAPTIVITY PANEL HARDWARE	EA	A	4
22	A1009144	AE140 SLEEVE FOR CAPTIVITY PANEL HARDWARE	EA	A	4
23	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE;0.032x0.250 TAB	EA	A	8
24	A1009488	AE210 JUMPER BAR, COMB TYPE, 2-POLE	EA	A	1
25	12212018	AE212 RING, #6, 22-18 INSUL	EA		3
26	12280005	OPX SCREW, #2-56 X 3/8 PH PHIL SS	EA		2
27	13128200	OPX NUT, 2/56 HEX	EA		2
28	13128250	OPX AB200 WASHER, #2 FLAT	EA		2
29	13128275	OPX AB200 WASHER, #2 INSIDE STAR	EA		2
30	12280059	OPX SCREW, 4-40 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		8
31	13128276	OPX WASHER, #4 INSIDE STAR	EA		10
32	13128201	OPX NUT, 4-40 HEX	EA		8
33	12280076	OPX SCREW, 4-40 X 1/4 FLAT PHILLIPS SS	EA		4
34	12280090	OPX NUT, 4-40 RADIO SIZE SST	EA		2
35	12280078	OPX SCREW, 4-40 X 3/8 FLAT PHIL SS	EA		2
36	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		7

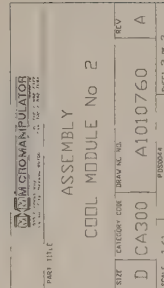
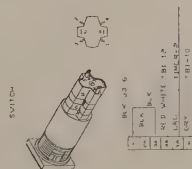
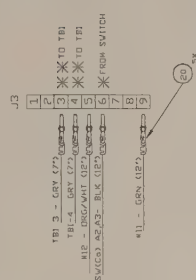
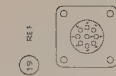
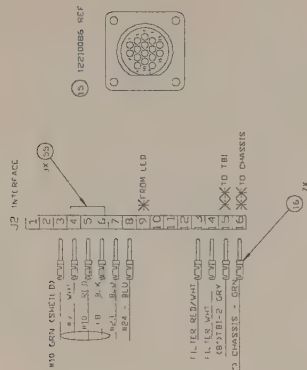
CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - D2C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
37	12280115	OPX SCREW, 6-32 X 1/2 PAN PLPS SS	EA		1
38	13128277	OPX WASHER, #6 INSIDE STAR	EA		1
39	12280152	OPX NUT, 6-32 RADIO SIZE SST	EA		1
40	13128189	OPX SCREW, 8-32 X 1-1/2 PHILLIPS DRIVE FLAT HEAD	EA		1
41	12280199	OPX WASHER, #8 FLAT	EA		3
42	13128278	OPX WASHER, #8 INSIDE STAR	EA		3
43	13128204	OPX AB200 NUT, 8-32 HEX	EA		3
44	A1008027	OPX AE600 CABLE, 4 COND, 24 AWG, SHIELDED BRAID	FT	A	2.5
45	12600008	OPX AE600 WIRE, 22 AWG 7 STRAND IRRAD PVC VIOLET	FT		2.5
46	12600007	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BLUE	FT		2.5
47	6002-0196-0	OPX WIRE, 22 WHT/BLK PRE-TINNED, ALPHA A3155	EA		2.5
48	6002-0190-0	OPX AE600 WIRE, 22 AWG WHITE & RED STRIPE	FT		2.5
49	12600010	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC WHITE	FT	A	2.5
50	12600009	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREY	FT		2.5
51	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		2.5
52	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		2.5
53	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		2.5
54	12600003	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC RED	FT		3
55	A1008032	AE210 CONTACT PIN, 24-26 AWG, F/CPC CONNECTOR	EA	A	2.5
56	A1011214	AG100 CHECK-OUT SHEET, COOL MODULE #2 TEST	EA		3
57	12280186	OPX SCREW, 8-32 X 3/8 PHILLIPS DRIVE FLAT HEAD	EA		A
58	A1009853	AE270 FILTER, RF1 120/240V 5A	EA		2
59	6100-16-2	OPX AE240 PLUG, HEYCO DOME, .250 DIAMETER	EA	C	A



MICROMANIPULATOR		PART TITLE	
ASSEMBLY, COOL MODULE No.2		CATEGORY CODE	
C CA300		A1010760	
SCALE 1/2		SHEET 1 OF 3	



CURRENT REVISION: B
CURRENT ECN: 45692
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009846	DA075 BOX, SRV TOP	EA	A	1
2	A1009847	DA075 BOX, SRV BOTTOM	EA	A	1
3	A1009812	DA075 PANEL, PLUMB. SERV. MODULE FRONT, SILKSCREEN	EA	A	1
4	12210030	AE210 RECEPTACLE, SQ. FLANGED, 9 PIN	EA		1
5	12210031	AE210 AE212 PIN, 20 AWG GOLD FLASH	EA		5
6	A1009811	PSY PANEL, PLUMB SERV MODULE REAR, SILKSCREEN	EA	A	1
7	12280318	AE280 PRESSURE REG., AIRWATER	EA		2
8	A1009839	AE280 BRACKET, MINIATURE MOUNTING W/RING	EA	A	2
9	12400022	AE400 VALVE, WATER 120 VAC	EA		2
10	12270002	AE270 FILTER, ORANGE DROP 0.1uF +-10% 400VDC 100ohm	EA		2
11	A1009840	AB100 FITTING, 1/4 MALE NPT TO 1/4 TUBE QUICK ON	EA	A	4
12	A1009841	AB100 FITTING, 1/8 MALE NPT TO 1/4 TUBE	EA	A	1
13	A1009842	AB100 FITTING, ELBOW 1/8 NPT TO 1/4 TUBE	EA	A	3
14	A1009843	AB100 FITTING, TEE 1/4 TUBE PUSH-ON	EA	A	2
15	A1009216	AE280 FOOT, RUBBER	EA	A	4
16	A1009849	AB100 TUBING, 1/4 O.D. NATURAL COLOR POLYETHYLENE	FT	A	3
17	A1009850	AB100 TUBING, 1/4" O.D. YELLOW POLYETHYLENE	FT	A	3
18	A1009801	AB100 COUPLING, QUICK CONNECT, PTF, 1/4" O.D. TUBE	EA	A	4
19	12212129	OPX BUTT SPLICE 22-16 AWG RED	EA		4
20	12212018	AE212 RING, #6, 22-18 INSUL	EA		1
21	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT		0.5
22	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT		0.5
23	12600009	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREY	FT		0.5
24	12280076	OPX SCREW, 4-40 X 1/4 FLAT PHILLIPS SS	EA		4
25	12280059	OPX SCREW, 4-40 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		4
26	13128276	OPX WASHER, #4 INSIDE STAR	EA		4
27	13128201	OPX NUT, 4-40 HEX	EA		4
28	12280115	OPX SCREW, 6-32 X 1/2 PAN PLPS SS	EA		1
29	13128277	OPX WASHER, #6 INSIDE STAR	EA		1

CURRENT REVISION: B
NO PENDING ENGINEERING CHANGES

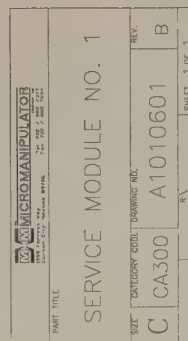
CURRENT ECN: 45692

DRAWING SIZE - C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
31	12280219	OPX AB200 SCREW, 10-32 X 1/4 PHIL DR PAN HD	EA		4
32	13128279	OPX WASHER, #10 INSIDE STAR	EA		8
33	12280216	OPX AB200 SCREW, 10-32 X 3/8 PHIL DR PAN HD	EA		4
34	13128267	OPX WASHER, #10 REGULAR FLAT (BLACK)	EA		4
35	13128205	OPX NUT, 10/32 HEX	EA		4
36	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		8
37	12280113	OPX SCREW, 6-32 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA		4
38	A1010812	AG100 TEST & CHECKOUT SHEET, SRV MODULE	EA	A	1
39	12280288	AE280 VALVE, CK	EA		1
40	A1010765	AB100 COUPLING, 1/4 NPT FEMALE BRASS	EA	A	1
41	13128352	OPX ADHESIVE, SILICONE CLEAR (2.8 oz.)	EA	A	0.25
51	A1010165	AG100 LABEL, CE MARK .875 INCH	EA	A	1
	12280285	AE280 SEE P/N A1009216 (FOOT, RUBBER, HH SMITH 2193)	EA	4.000000	SUB



CUT	TUBING	CHART	COLOR	LENGTH	QTY.
			CLEAR	1"	1
			CLEAR	4"	1
			CLEAR	11"	1
			CLEAR	12"	1
			YELLOW	2"	1
			YELLOW	2.5"	1
			YELLOW	7"	1
			YELLOW	11"	2



CURRENT REVISION: A

CURRENT ECN: DLH

NO PENDING ENGINEERING CHANGES

DRAWING SIZE - D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010772	AE260 ASSEMBLY, FAN, HEAT EXCHANGER	EA	A	1
2	A1010773	AB550 PUMP, MOTOR	EA	A	1
3	A1010774	AB700 BOTTLE, RESERVOIR	EA	B	1
4	A1010776	AB150 TUBING, 3/8 I.D., 5/8 O.D.	FT	A	5
6	A1010778	AB150 FITTING, 1/4 NPT 90 DEG. 1/4 TUBING O.D.	EA	A	1
7	A1010780	PSY CHASSIS	EA	A	1
8	A1010167	AE390 5 FUNCTION POWER INLET MODULE	EA	A	1
9	A1009487	AE210 TERMINAL STRIP, CAGE CLAMP 3-CKT'S OF 4 COND	EA	A	3
10	12400022	AE400 VALVE, WATER 120 VAC	EA	2	1
11	12280318	AE280 PRESSURE REG., AIR/WATER	EA	1	1
12	A1009839	AE280 BRACKET, MINIATURE MOUNTING W/RING	EA	A	1
13	12210030	AE210 RECEPTACLE, SQ. FLANGED, 9 PIN	EA	1	1
14	12270002	AE270 FILTER, ORANGE DROP 0.1uF +-10% 400VDC 100ohm	EA	3	1
15	A1009849	AB100 TUBING, 1/4 O.D. NATURAL COLOR POLYETHELENE	FT	A	12
16	A1009840	AB100 FITTING, 1/4 MALE NPT TO 1/4 TUBE QUICK ON	EA	A	3
17	A1009841	AB100 FITTING, 1/8 MALE NPT TO 1/4 TUBE	EA	A	1
18	A1009801	AB100 COUPLING, QUICK CONNECT, PTF, 1/4" O.D. TUBE	EA	A	3
19	A1009807	AB100 COUPLING, QUICK CONNECT, H.T. M HSB 3/16 HOSE	EA	A	2
20	A1009843	AB100 FITTING, TEE 1/4 TUBE PUSH-ON	EA	A	2
21	12280078	OPX SCREW, 4-40 X 3/8 FLAT PHIL SS	EA	4	1
22	A1010707	DA075 COVER, TOP	EA	A	1
23	A1010779	PSY COVER, FILL	EA	A	1
24	A1010706	PSY BRACKET, BOTTLE	EA	A	1
25	A1010702	DA050 PLATE, PUMP MOUNT	EA	A	1
26	A1010705	PSY PANEL, 17 INCH FRONT C1000 HEAT EXCHANGER	EA	A	1
27	A1010764	AB100 TEE, 1/4 FNPT BRASS	EA	A	1
28	A1010876	AB100 ADAPTER, 3/8" HOSE BARB TO 1/4 MALE NPT BRASS	EA	A	2
29	A1010900	AB100 ADAPTER, 3/16 HOSE BARB TO 1/4 NPT	EA	A	4

CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

CURRENT ECN: DLH

DRAWING SIZE - D

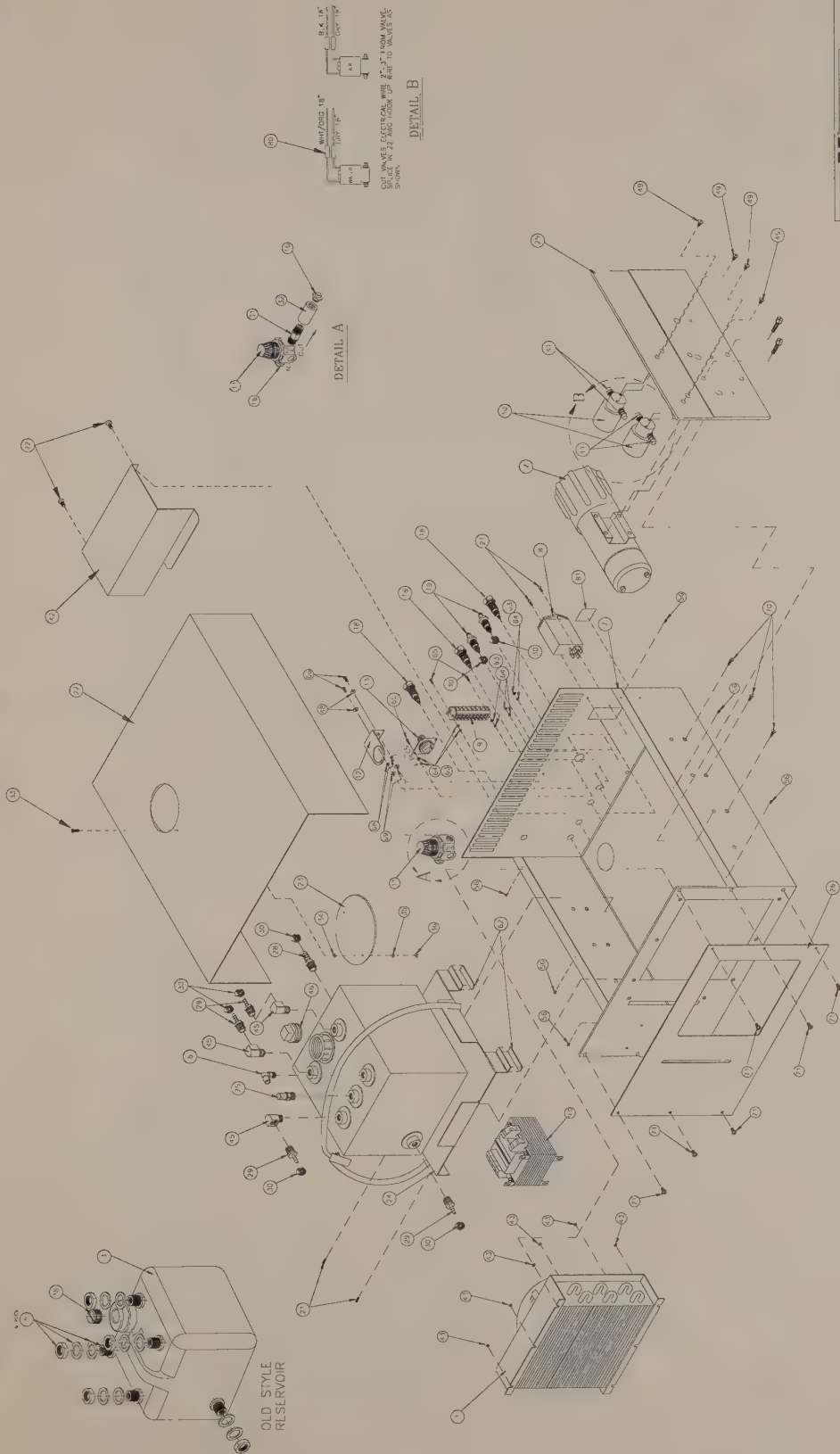
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30	A1010878	AB200 CLAMP, 5/8 HOSE GEAR TYPE	EA	A	8
31	12280288	AE280 VALVE, CK	EA	1	1
32	A1009158	AB100 COUPLING, 1/4 NPT	EA	A	1
33	12280080	OPX SCREW, 4-40 X 1/2 FLAT PHILLIPS SS	EA	1	1
34	13128292	OPX WASHER, #4 FLAT BRASS (.120 X .280 X .025T)	EA	1	1
35	12280091	OPX WASHER, #4 FLAT SS	EA	7	1
36	A1008230	AB200 NUT, 4-40, HEX, LOCK, NYLON	EA	A	1
37	12240004	AE240 PLATE, SERIAL NO.	EA	1	1
39	12275031	AE275 FUSE, 2A SLO-BLO, GLASS	EA	1	1
40	2800-0125	DA075 NIPPLE, 10/32	EA	B	1
41	A1009842	AB100 FITTING, ELBOW 1/8 NPT TO 1/4 TUBE	EA	A	4
42	A1011056	AA050 COVER, ELECTRICAL, HEAT EXCHANGER	EA	A	1
43	A1011108	OPX NUT, 6-32 KEP, SST	EA	11	1
44	A1011107	OPX NUT, 4-40 KEP, SST	EA	8	1
45	A1010767	AB100 ELBOW, 1/4 NPT BRASS STREET	EA	A	3
46	A1011429	AB100 PLUG, 1-1/2" NPT PVC OR ABS CLEAN OUT	EA	1	1
48	12280145	OPX WASHER, #6 FLAT	EA	5	1
49	A1009263	OPX SCREW, 10-32 X 1/2 FLAT HEAD SOC. DRIVE, SST	EA	A	4
50	A1000958	OPX SCREW, 8-32 X 1/2 SOCKET DRIVE FLAT HEAD	EA	3	1
51	13128166	OPX SCREW, 6-32 X 3/8 SOCKET DRIVE BUTTON HEAD	EA	3	1
52	A1001353	OPX AB200 SCREW, 4-40 X 3/8 SOC DR BUTTON HD BLK	EA	6	1
53	13128183	OPX AB200 SCREW, 4-40 X 1/2 SOC DR FLAT HD	EA	2	1
54	13128135	OPX SCREW, 4-40 X 3/8 SOCKET HEAD FLAT	EA	2	1
55	12280216	OPX AB200 SCREW, 10-32 X 3/8 PHIL DR PAN HD	EA	6	1
56	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA	6	1
57	6000-0146	OPX TUBING, 3/16" CLEAR TYGON	FT	A	2
58	12280258	OPX MOUNT, ADHESIVE BACK TIE WRAP	EA	6	1
59	A1005941	OPX SCREW, 4-40 X 1/4 BUTTON HEAD SOCKET	EA	A	2
60	26065006	OPX CLAMP, 5-16	EA	2	1
61	A1011286	AB200 CLAMP, 7/8 MAX HOSE, GEAR TYPE	EA	A	2
62	A1011063	AB700 TAPE, HEAVY DUTY, DOUBLE SIDED FOAM MOUNTING	IN	A	0.01
63	12280090	OPX NUT, 4-40 RADIO SIZE SST	EA	4	1

CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

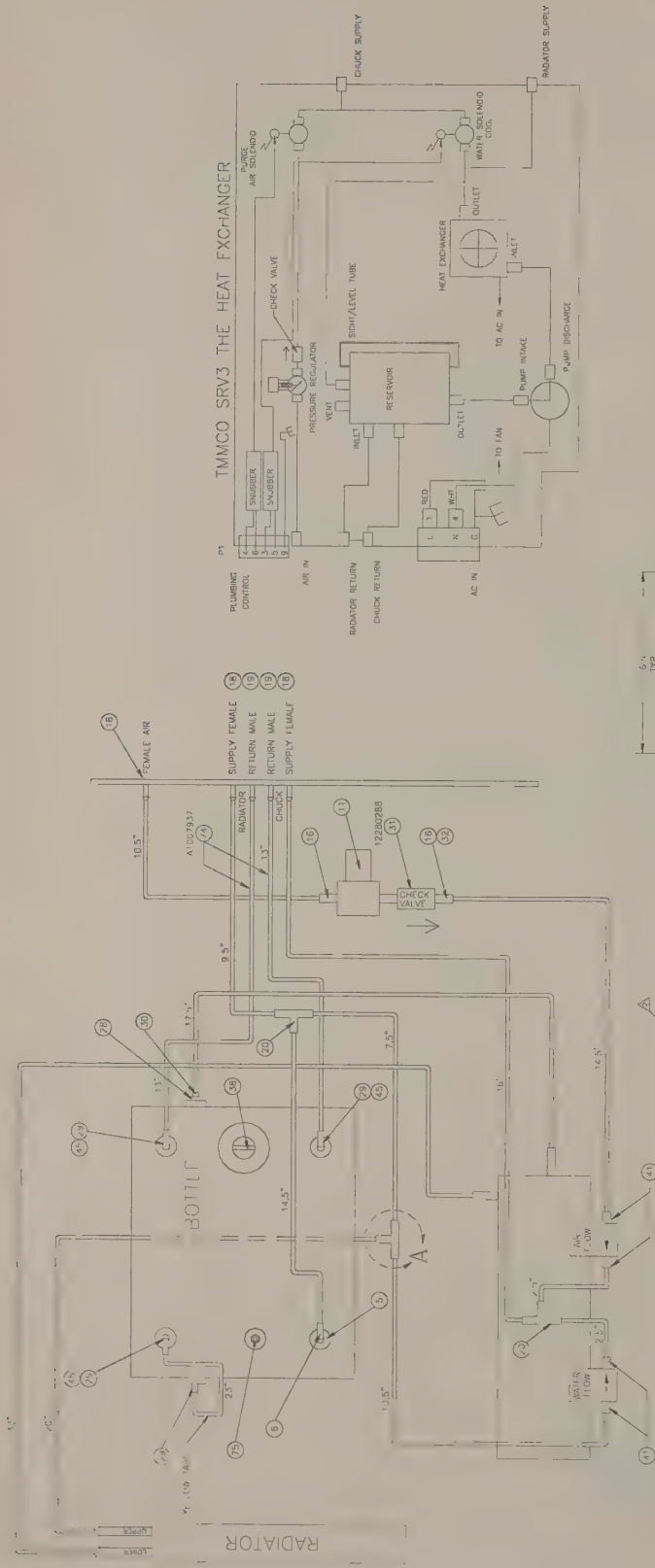
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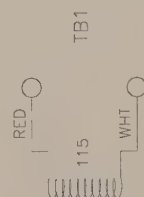
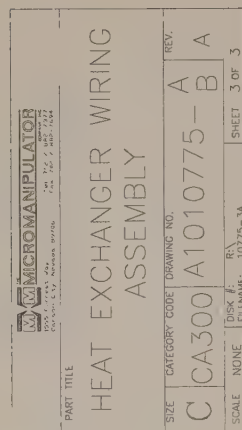
DRAWING SIZE - D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
64	13128276	OPX WASHER, #4 INSIDE STAR	EA	4	1
65	12280059	OPX SCREW, 4-40 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA	2	1
66	12280113	OPX SCREW, 6-32 X 3/8 PHILLIPS DRIVE PAN HEAD SST	EA	2	1
68	12280147	OPX WASHER, #6 SPLIT LOCK SST	EA	2	1
69	12280149	OPX NUT, 6-32 HEX	EA	2	1
70	A1009044	OPX SCREW, 8-32 X 1/2 SOCKET DRIVE FLAT HEAD, SST	EA	A	3
71	13128187	OPX SCREW, 10-32 X 3/8 PHIL. DR. PAN HD., SST	EA	6	1
72	12280057	OPX SCREW, 4-40 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA	2	1
73	A1010165	AG100 LABEL, CE MARK .875 INCH	EA	A	1
74	A1007937	OPX TUBING, 3/8 OD, 3/16 ID, LOW TEMP. SILICONE	FT	A	2
75	6001-0071	AB100 MUFFLER	EA	A	1
80	12212129	OPX BUTT SPLICE 22-16 AWG RED	EA	4	1
81	6004-0003-0	OPX AE600 CABLE, 2CNDR SHLD ALPHA 2254 BLDN 8737	FT	2	1
82	12600001	OPX WIRE, 22 AWG, 7 STRAND, IRRAD PVC BLACK	FT	3	1
83	6002-0191-0	OPX AE600 WIRE, 22 AWG WHITE & ORANGE STRIPE	FT	3	1
84	12600009	OPX WIRE, 22			



PART FILE MICROMANIPULATOR 12-74-1-100-100			
ASSEMBLY, HEAT EXCHANGER			
PART D	DRAWING CODE A101075-B	REV A	SHEET 1 OF 3





ALL WIRES NEED TO
BE 22 AWG

230 VERSION

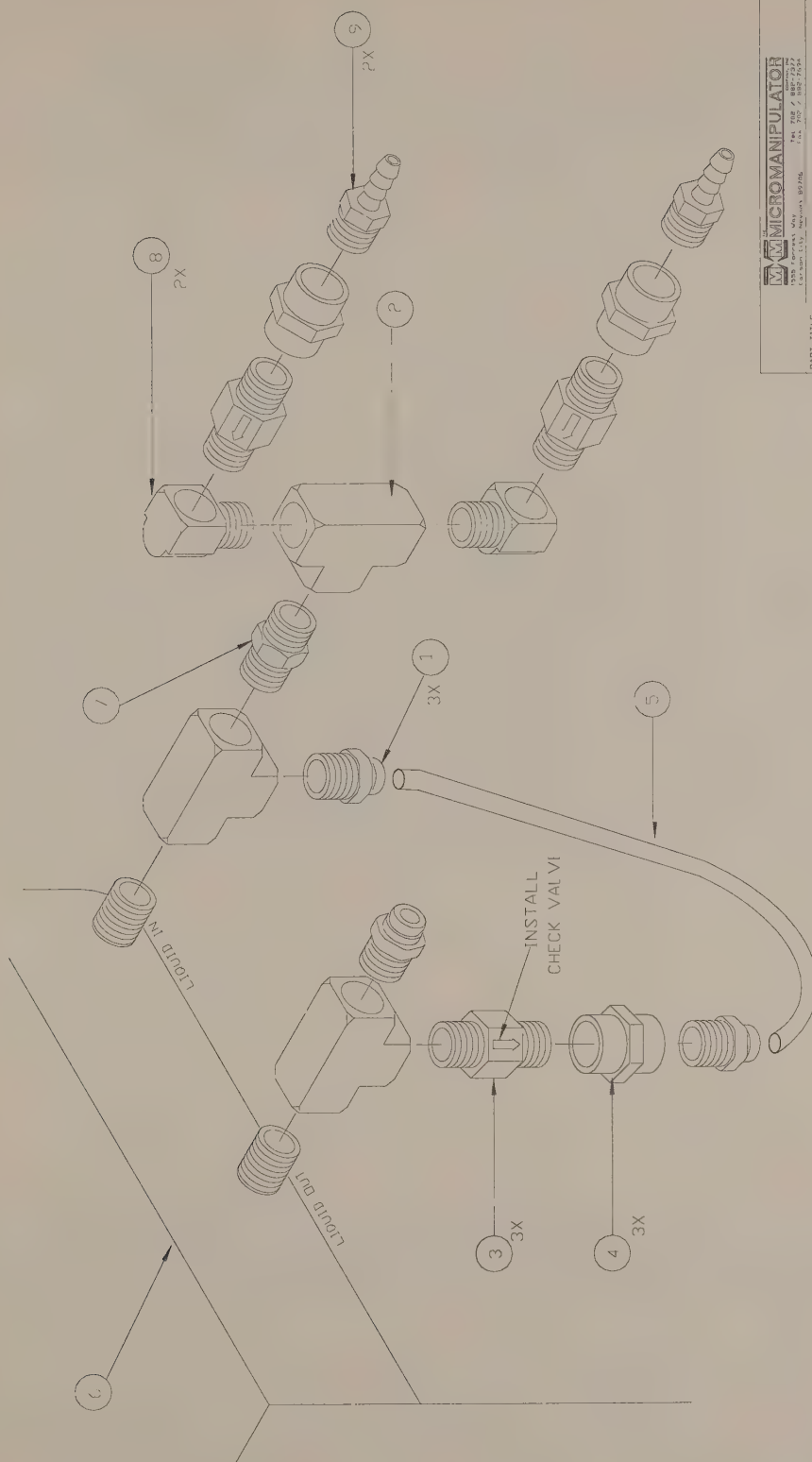
CURRENT REVISION: A

CURRENT ECN: DLH

NO PENDING ENGINEERING CHANGES

DRAWING SIZE - B

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009840	AB100 FITTING, 1/4 MALE NPT TO 1/4 TUBE QUICK ON	EA	A	3
2	A1010764	AB100 TEE, 1/4 FNPT BRASS	EA	A	3
3	12280288	AE280 VALVE, CK	EA		3
4	A1010765	AB100 COUPLING, 1/4 NPT FEMALE BRASS	EA	A	3
5	A1009849	AB100 TUBING, 1/4 O.D. NATURAL COLOR POLYETHELENE	FT	A	1
6	A1010758-A	AE530 COOLER, 110V MEDIUM RECIRCULATING	EA		1
7	A1010766	AB100 NIPPLE, 1/4 NPT BRASS HEX	EA	A	1
8	A1010767	AB100 ELBOW, 1/4 NPT BRASS STREET	EA	A	2
9	A1010768	AB100 BARB, BRASS 1/4 MNPT TO 3/16 HOSE	EA	A	2
11	A1002151	OPX TAPE, TEFLON THREAD SEAL 1/4 WIDE	EA		0.05



MICROMANIPULATOR 1000 UNIVERSITY AVENUE SUITE 100 ANN ARBOR, MI 48106-1500 TEL: 313/763-7227 FAX: 313/763-7227		PART TITLE ASSLMB. Y. MODIFIED MED JM CHILLER	
SIZE B	CATEGORY CODE CA300	DRAWING NO. A1010769 A\B	REV A
SCALE 1/1	DISK # E:VPSS0044	FILENAME 10769-1A	SHEET 1 OF 1

CURRENT REVISION: A

CURRENT ECN: DLH

NO PENDING ENGINEERING CHANGES

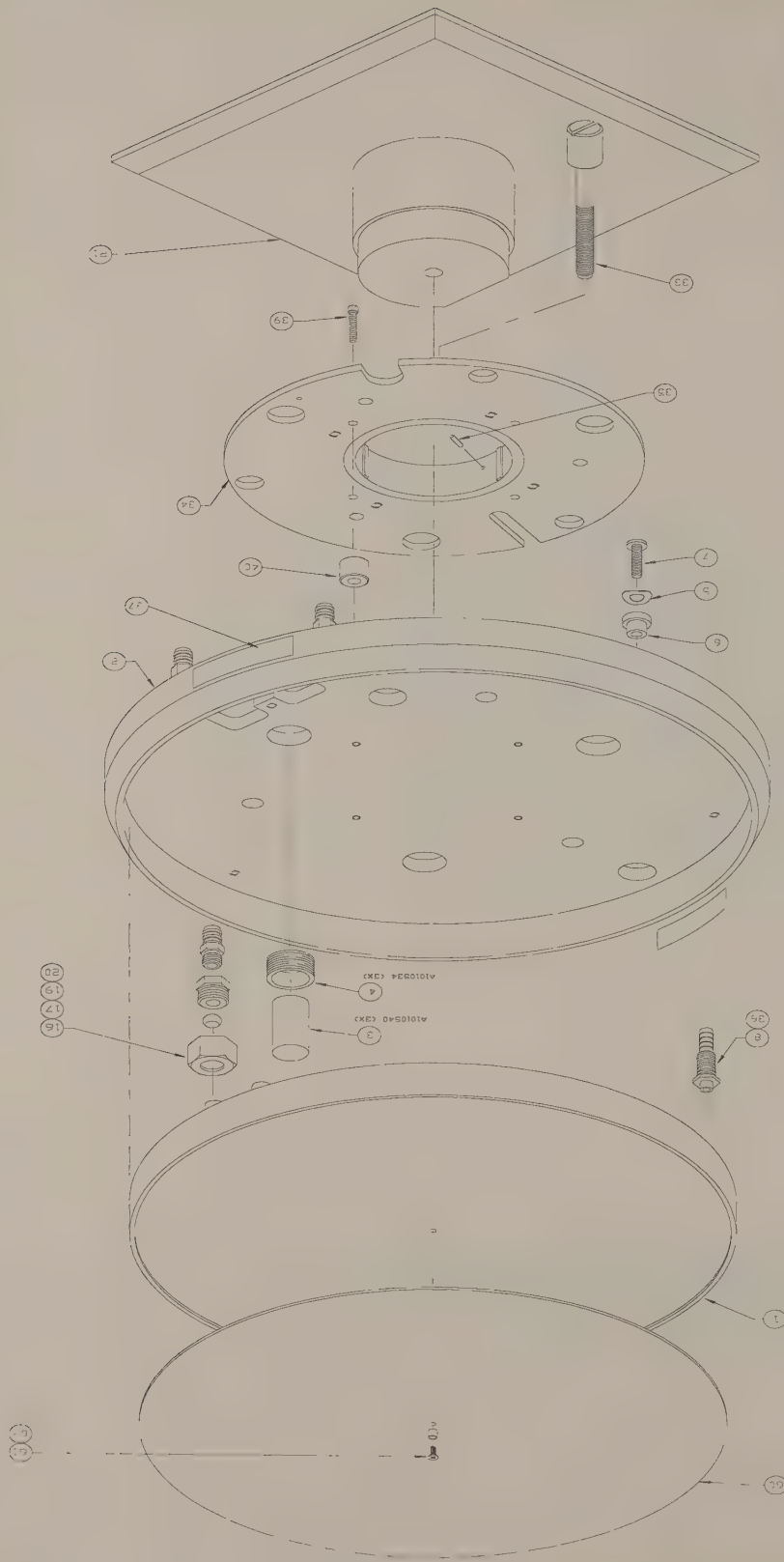
DRAWING SIZE - 3D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010448	DA050 PUCK, 8" MACHINED FOR STANDARD ASSY. 120V	EA	A	1
2	A1010579	CA250 ASSEMBLY, 8" WELDED RADIATOR	EA	A	1
3	A1010540	AB700 POST, SAPPHIRE SUPPORT	EA	A	3
4	A1010534	DA050 HOLDER, SAPPHIRE STANDOFF	EA	A	3
5	A1010537	AB200 WASHER, #6 CURVED	EA	A	3
6	A1010533	AE310 WASHER, #6 CERAMIC SHOULDER	EA	A	3
7	A1010633	AB200 SCREW, 6-32 X 5/8 SOCKET DRIVE BUTT HEAD, SS	EA	A	3
8	A1010539	DA050 FITTING, VACUUM 10-32	EA	B	1
9	A1009837	DA050 SCREW, MODIFIED T/C MOUNTING	EA	A	1
10	A1009859	CA200 ASSEMBLY, HIGH ISOLATION DUAL "K"	EA	B	1
11	A1011430	AE530 CLASS A, DUAL RTD ASSEMBLY	EA	A	1
12	A1009808	AB100 COUPLING, QUICK CONNECT, HT F HSB 3/16 ID HOSE	EA	A	2
13	A1009806	AB100 COUPLING, QUICK CONNECT, BRASS "W" HSB 1/8 HOSE	EA	A	2
14	A1008200	AB100 HOSE, 3/16 I.D. RED SILICON GRADE HT	FT	A	2
15	A1007936	AB100 LOW TEMP SILICON TUBING 1/8 ID, 5/16 OD	FT	A	2
16	A1010582	PSY NUT, NICKEL PLATED 1/4" COMPRESSION	EA	A	2
17	A1010583	AB100 SLEEVE, 1/4" COMPRESSION	EA	A	2
18	A1010575	AB100 CLAMP, HOSE	EA	A	8
19	A1010573	DA050 FITTING, COOLING TUBE	EA	A	2
20	6000-0145	PSY NIPPLE, 1/4"-28 VACUUM HOSE	EA	B	2
21	A1010574	CA250 ASSEMBLY, 8" CHUCK STAND	EA	A	1
23	A1009130	OPX WIRE, 16 AWG WHITE TEFLON INSULATED	FT	A	2
24	A1008459	AE212 SPLICE, BUTT NON-INSULATED 14-16 AWG	EA	A	2
25	12210103	AE210 CONNECTOR, UMC FEMALE	EA		1
26	6004-0017-0	OPX AE600 CABLE, SHIELDED RG 174/U BELDEN 8216	FT		1
27	A1002166	AE212 TERMINAL, RING #6 (T&B A85)	EA	A	5
28	A1004420	AE210 CONNECTOR, HOUSING, MALE, 10 POS.	EA	A	1
29	A1004421	AE210 CONNECTOR, CONTACT, FEMALE SOCKET,	EA	A	8
30	A1010441	AE210 CONTACT, FEMALE 16 AWG MOLEX JR. FIT	EA	A	2
33	A1010542	CA250 ASSEMBLY, THETA LOCKSCREW	EA	A	1
34	A1010532	AA050 HUB, 8" HOT CHUCK	EA	C	1
35	13128307	OPX PIN, 1/16 DIA X 1/2 DOWEL	EA	A	1
36	A1007077	AC700 SILICON, HI-TEMP, RTV GASKET	EA	A	0.05

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

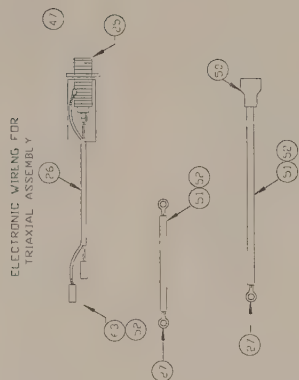
DRAWING SIZE - 3D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
37	A1010347	AG100 LABEL, CAUTION HOT! 1/2 X 2.0"	EA	A	2
39	13128074	OPX SCREW, 4-40 X 1.0 SOCKET HEAD CAP	EA		4
40	A1010578	AA050 SPACER, HUB/RADIATOR	EA	A	4
41	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		2
42	12600073	OPX SLEEVEING,WOVEN GLASS INSULATING BLACK	FT		2
43	12600087	OPX TUBING, 3/16 BLACK SHRINK	FT		1
44	13128277	OPX WASHER, #6 INSIDE STAR	EA		2
46	12600076	AE600 SLEEVEING,#2 (5/16) GLASS BLACK	FT		1
47	12600083	OPX AE600 SLEEVEING, 3/8 X 1 SHRINK	FT		1
48	13128098	OPX SCREW, 1/4-28 X 1/4 SOCKET HEAD CUP POINT SET	EA		1
49	12600071	AE600 SLEEVEING, #16 GLASS 1/16 BLACK	FT		1
50	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE,0.032x0.250 TAB	EA	A	1
51	A1008220	OPX AE600 BRAID,1/8" WIDE TINNED COPPER FLAT	FT	A	1
52	12600081	OPX TUBING, 1/8 OD BLACK SHRINK	FT		1
53	16306001	OPX AC700 COMPOUND, THERMAL GS ELEC	OZ	A	0.2
54	2800-0073	OPX HOSE, 1/8 I.D. RED SILICONE	FT		0.7
55	A1011024	AG100 CHECK OUT SHEET, H1000 ASSEMBLY	EA	A	1
99	A1009045	AG100 PROCEDURE, 8000 SERIES CHUCK PLANARIZING	EA	C	1



PART TITLE		CHUCK, 8"	
ADV, HPI, 8800 SFR.FS		SEE C-ART	
SIZE	CATEGORY CODE	REV. NO.	REV. NO.
D	DA050	CHK8800-8...	B
SCALE	NOTE	TOLERANCE	SHEET 1 OF 3

PART NO. CHART	CHART NO. CHART
CHART NO. CHART	CHART NO. CHART
CHART NO. CHART	CHART NO. CHART
CHART NO. CHART	CHART NO. CHART

ELECTRONIC WIRING FOR
TRIAXIAL ASSEMBLY

PART NO	CHART
CHK8800-8XC	
CHK8800-8XC-V2	
CHK8800-8T	
CHK8800-8T-V2	

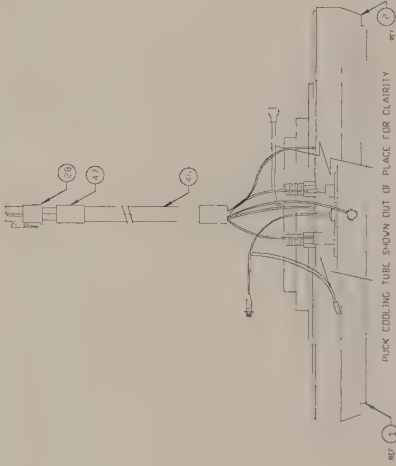
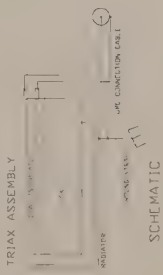
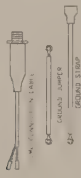
MM MICROMANIPULATOR
145 102 / 102.033
100 100 / 100.033

CHUCK, 8 INCH,
ADV, HOT, 8800 SERIES

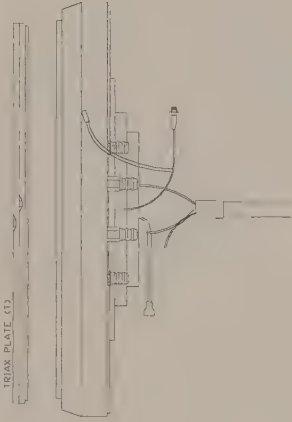
SIZE	CATEGORY CODE	BRAVING NO	SEE CHART	REV
D	DA050		CHK8800-8...	B
SCALE	NONE	BY	DATE	SHEET 2 OF 3

ELECTRONIC WIRING FOR
ADVANCED COAX ASSEMBLY

ELECTRONIC WIRING FOR

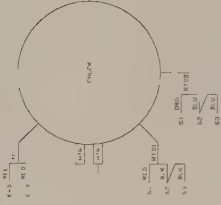
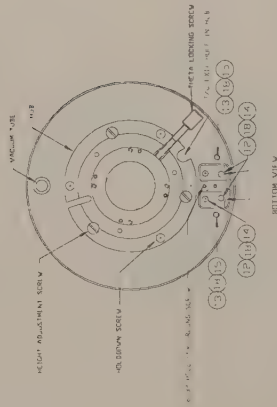


ADVANCED COAX PLATE (CD) □ FINALLY PLAMARIZE ASSEMBLY USE SHIP FIXTURE.



6	RED	16AWG	1	RED	16AWG
7	RED	16AWG	2	RED	16AWG
8	RED	16AWG	3	RED	16AWG
9	RED	16AWG	4	RED	16AWG
10	RED	16AWG	5	RED	16AWG
11	RED	16AWG	6	RED	16AWG
12	RED	16AWG	7	RED	16AWG
13	RED	16AWG	8	RED	16AWG
14	RED	16AWG	9	RED	16AWG
15	RED	16AWG	10	RED	16AWG

THERMOCOUPLE WIRING ONLY



BLU 2	RTD 2	HT 2	10	16 AWG
BLU 4	RTD 4	HT 4	9	BLU
BLU 3	RTD 3	HT 3	8	BLU
DRG 2	HT 2	RTD 2	7	RED
DRG 1	HT 1	RTD 1	6	RED

DATE	NO. 000001
CHANGED	REC-1
CHANGED	REC-2
CHANGED	REC-3

CHUCK, 8 INCH,
ADV, HOT, 8800 SERIES
D 00000 CHK800-B... B

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - 3D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010450-A	DA050 PUCK, 6" MACHINED FOR STANDARD ASSY. 120V	EA	A	1
2	A1010644	CA250 ASSEMBLY, 6" RADIATOR - WELDED	EA	A	1
3	A1010540	AB700 POST, SAPPHIRE SUPPORT	EA	A	3
4	A1010534	DA050 HOLDER, SAPPHIRE STANDOFF	EA	A	3
5	A1010537	AB200 WASHER, #6 CURVED	EA	A	3
6	A1010533	AE310 WASHER, #6 CERAMIC SHOULDER	EA	A	3
7	A1010633	AB200 SCREW, 6-32 X 5/8 SOCKET DRIVE BUTT HEAD, SS	EA	A	3
8	A1010539	DA050 FITTING, VACUUM 10-32	EA	B	1
9	A1009837	DA050 SCREW, MODIFIED T/C MOUNTING	EA	A	1
10	A1009859	CA200 ASSEMBLY, HIGH ISOLATION DUAL "K"	EA	B	1
11	A1011430	AE530 CLASS A, DUAL RTD ASSEMBLY	EA	A	1
12	A1009808	AB100 COUPLING, QUICK CONNECT, HT F HSB 3/16 ID HOSE	EA	A	1
13	A1009806	AB100 COUPLING, QUICK CONNECT, BRASS "M" HSB 1/8 HOSE	EA	A	1
14	A1008200	AB100 HOSE, 3/16 I.D. RED SILICON GRADE HT	FT	A	5
15	A1007936	AB100 LOW TEMP SILICON TUBING 1/8 ID, 5/16 OD	FT	A	5
16	A1010582	PSY NUT, NICKEL PLATED 1/4" COMPRESSION	EA	A	2
17	A1010583	AB100 SLEEVE, 1/4" COMPRESSION	EA	A	2
18	A1010575	AB100 CLAMP, HOSE	EA	A	8
19	A1010573	DA050 FITTING, COOLING TUBE	EA	A	2
20	6000-0145	PSY NIPPLE, 1/4"-28 VACUUM HOSE	EA	A	2
21	A1010574	CA250 ASSEMBLY, 8" CHUCK STAND	EA	B	1
23	A1009130	OPX WIRE, 16 AWG WHITE TEFLON INSULATED	EA	A	2
24	A1008459	AE212 SPLICE, BUTT NON-INSULATED 14-16 AWG	FT	A	2
25	12210103	AE210 CONNECTOR, UMC FEMALE	EA	A	2
26	6004-0017-0	OPX AE6000 CABLE, SHIELDED RG 174/U BELDEN 8216	EA		1
27	A1002166	AE212 TERMINAL, RING #6 (T&B A85)	FT		1
28	A1008454	AE210 CONN, AMP CPC 16 POS FREE HANGING RECEPTACLE	EA	A	5
29	12210076	AE210 CONTACT PIN, 20-24 AWG, F/CPC CONNECTOR	EA	A	1
30	12210075	AE210 CONTACT, PIN, 16-18 AWG, F/CPC CONNECTOR	EA		8
31	A1008032	AE210 CONTACT PIN, 24-26 AWG, F/CPC CONNECTOR	EA		2
32	12210088	AE210 SHELL, SIZE 17 CABLE	EA	A	2
33	A1008445	CA250 ASSEMBLY, 6" THETA LOCKSCREW	EA	A	1
34	A1010647	AA050 HUB, 6" HOT CHUCK	EA	A	1

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - 3D

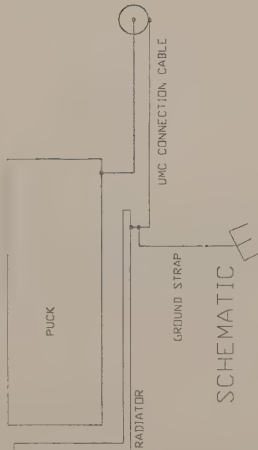
ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
35	13128307	OPX PIN, 1/16 DIA X 1/2 DOWEL	EA	A	1
36	A1007077	AC700 SILICON, HI-TEMP, RTV GASKET	EA	A	0.05
37	A1010347	AG100 LABEL, CAUTION HOT! 1/2 X 2.0"	EA	A	2
39	13128074	OPX SCREW, 4-40 X 1.0 SOCKET HEAD CAP	EA		3
40	A1010578	AA050 SPACER, HUB/RADIATOR	EA	A	3
41	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		2
42	12600073	OPX SLEEVEING,WOVEN GLASS INSULATING BLACK	FT		2
43	12600087	OPX TUBING, 3/16 BLACK SHRINK	FT		1
44	13128277	OPX WASHER, #6 INSIDE STAR	EA		2
46	12600076	AE600 SLEEVEING,#2 (5/16) GLASS BLACK	FT		1
47	12600083	OPX AE600 SLEEVEING, 3/8 X 1 SHRINK	FT		1
48	13128115	OPX SCREW, 1/4-28 X 3/16 SOCKET HEAD CUP POINT SET	EA		1
49	12600071	AE600 SLEEVEING, #16 GLASS 1/16 BLACK	FT		1
52	12600081	OPX TUBING, 1/8 OD BLACK SHRINK	FT		1
53	16306001	OPX AC700 COMPOUND, THERMAL GS ELEC	OZ	A	0.2
54	2800-0073	OPX HOSE, 1/8 I.D. RED SILICONE	FT		2
55	A1011024	AG100 CHECK OUT SHEET, H1000 ASSEMBLY	EA	A	1
56	A1009807	AB100 COUPLING,QUICK CONNECT,H.T. M HSB 3/16 HOSE	EA	A	1
57	A1009803	AB100 COUPLING,QUICK CONNECT,"F" HSB 1/8 I.D. HOSE	EA	A	1

ELECTRONIC WIRING FOR

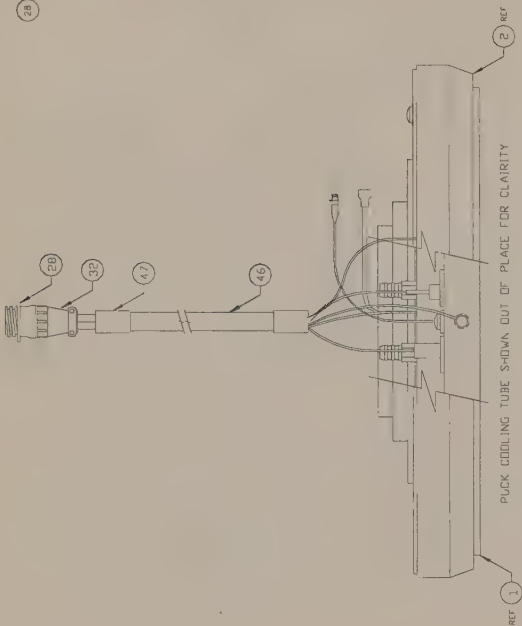
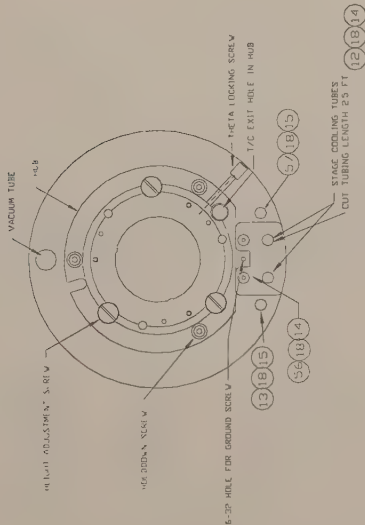


UMC CONNECTION CABLE

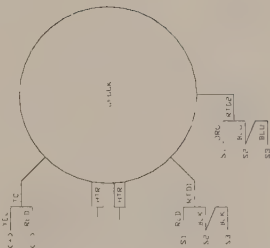
BASIC COAX ASSEMBLY



SCHEMATIC

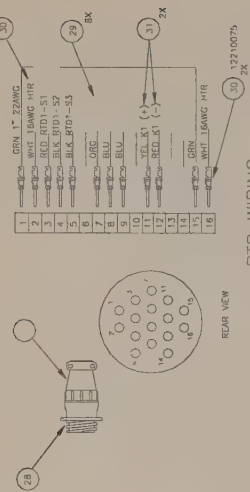


PUCK COOLING TUBE SHOWN OUT OF PLACE FOR CLARITY



PUCK COOLING TUBE

CUT TUBING LENGTH 25 FT



RTD WIRING

REAR VIEW

PART TITLE		REV	
ASSEMBLY, 6" COAX		REV	
THERMAL CHUCK, NON 8800		REV	
DATE	EXAMINED	DATE	REV
D	CF0055	A1010896-A	A
SIGNATURE	NONE	10/24/96	10/24/96

CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

CURRENT ECN: DLH

DRAWING SIZE - C

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010808	DA075 PANEL, GPIB INTERFACE MODULE FRONT	EA	A	1
2	A1010809	AE200 CONTROLLER, GPIB/422 INTERFACE	EA	A	1
3	A1010810	CA200 ASSY., CIRCUIT BOARD, GPIB/422 POWER SUPPLY	EA	A	1
4	12280080	OPX SCREW, 4-40 X 1/2 FLAT PHILLIPS SS	EA		4
5	12280091	OPX WASHER, #4 FLAT SS	EA		4
6	12280057	OPX SCREW, 4-40 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		2
7	12280076	OPX SCREW, 4-40 X 1/4 FLAT PHILLIPS SS	EA		4
8	A1007417	AE210 CONN, CONTACT RECEPTACLE, 26-22 AWG	EA	A	21
9	A1007418	AE210 CONN, LOW PROFL. RECEPT. 8 POS., 2.5mm PITCH	EA	A	3
10	12210028	AE210 SOCKET, 20 GA. GOLD FLASH	EA		5
11	A1007543	AE210 CONN, 9 POS, D-SUB, PLUG W/O SOCKETS	EA	A	1
12	12280005	OPX SCREW, #2-56 X 3/8 PH PHIL SS	EA		4
13	13128275	OPX AB200 WASHER, #2 INSIDE STAR	EA		4
14	13128200	OPX NUT, 2/56 HEX	EA		4
15	12210034	AE210 RECEPTACLE-VIKING, TFR07-101-P	EA		2
16	12210036	AE210 CONTACT, MALE-VIKING, TP100-AU	EA		14
17	A1009825	DA075 PANEL, RS422 INTERFACE REAR	EA	A	1
18	A1009846	DA075 BOX, SRV TOP	EA	A	1
19	A1009858	DA075 BOX, RS422 CONVERTER	EA	A	1
20	A1010503	OPX AE600 CABLE, 6 COND., 24 AWG SHIELDED	EA	A	1
21	12280113	OPX SCREW, 6-32 X 3/8 PHILLIPS DRIVE PAN HEAD SST	FT	A	2
22	A1009216	AE280 FOOT, RUBBER	EA		4
23	13128276	OPX WASHER, #4 INSIDE STAR	EA	A	4
24	13128201	OPX NUT, 4-40 HEX	EA		6
25	A1007684	AE280 SPACER, #4 x 3/16" x 1/8" LONG, NYLON	EA	A	4
26	6002-0190-0	OPX AE600 WIRE, 22 AWG WHITE & RED STRIPE	FT		0.33
27	6002-0194-0	OPX AE600 WIRE, 22 AWG WHITE & BROWN STRIPE	FT		0.33
28	12600006	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC GREEN	FT		0.33
29	12600004	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC ORANGE	FT		0.33
30	12600005	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC YELLOW	FT		0.33
31	12600002	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC BROWN	FT		0.33

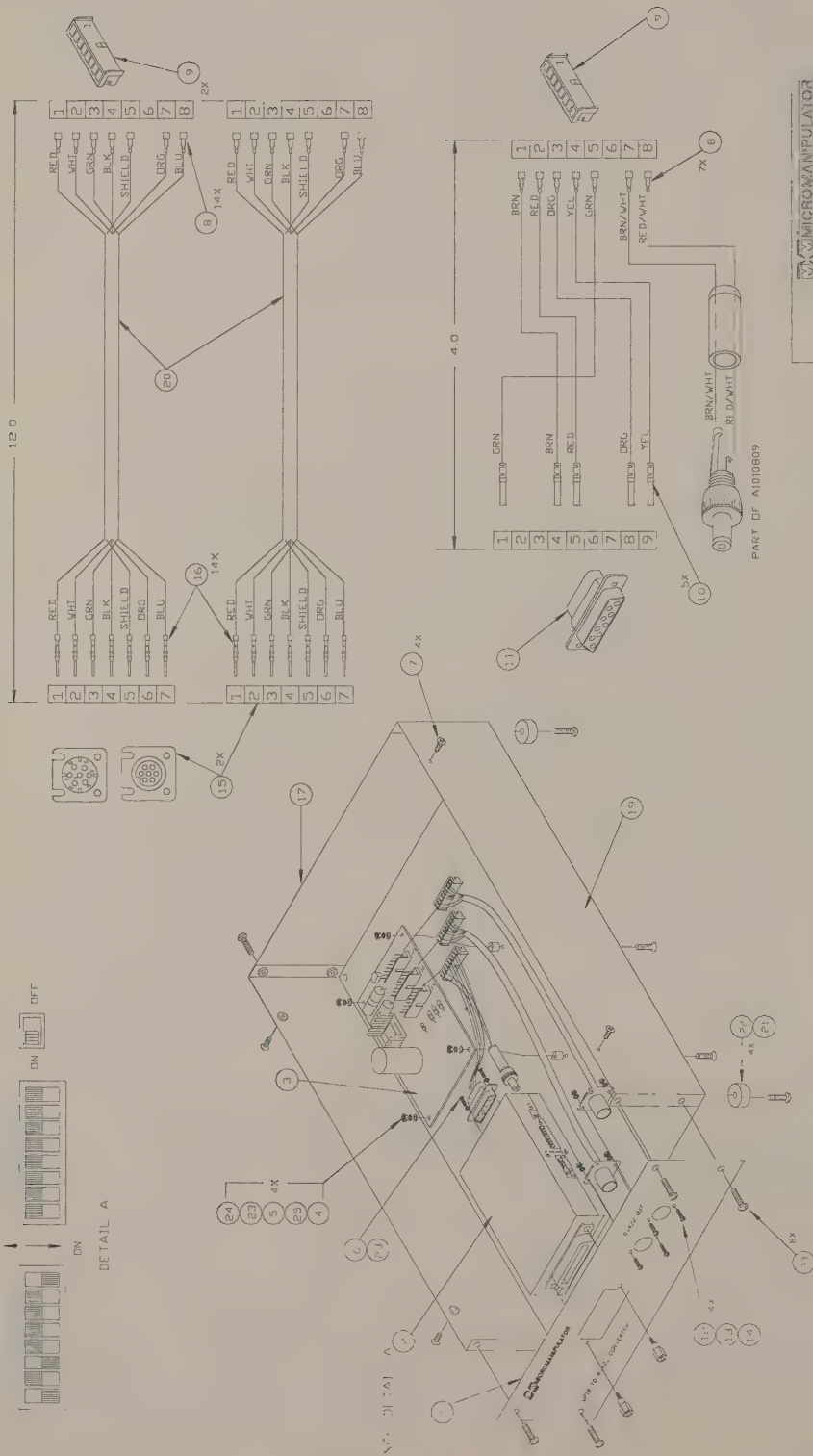
CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - C

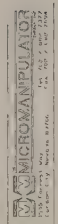
ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
32	12600003	OPX WIRE, 22 AWG 7 STRAND IRRAD PVC RED	FT		0.33
33	12280111	OPX SCREW, 6-32 X 1/4 PHILLIPS DRIVE PAN HEAD SST	EA		8
34	A1011418	AG100 TEST & CHECK-OUT SHEET, RS422 INTERFACE	EA	A	1
	12280285	AE280 SEE P/N A1009216 (FOOT, RUBBER, HH SMITH 2193)	EA		4.000000
	ITEM 22				SUB



DETAIL A



PART TITLE		REV	
MODULE, GPIB TO 422		A	
SIZE	CATEGORY CODE	DRAWING NO	
C	CA300	A1010807	
SCALE	1/2	PERS/DWG	SHEET 1 OF 1
		FILENAME	10807-JA



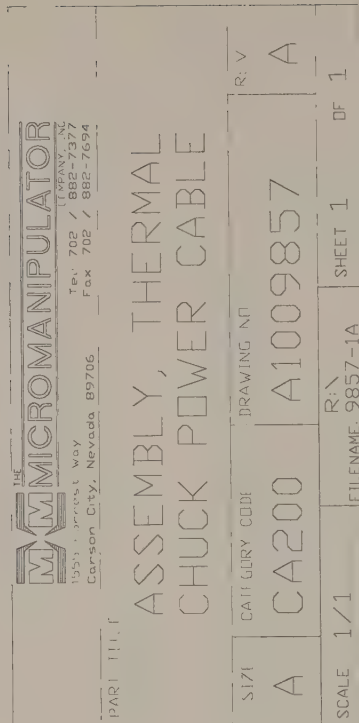
MODULE, GPIB TO 422

PART TITLE		REV	
MODULE, GPIB TO 422		A	
SIZE	CATEGORY CODE	DRAWING NO	
C	CA300	A1010807	
SCALE	1/2	PERS/DWG	SHEET 1 OF 1
		FILENAME	10807-JA

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - A

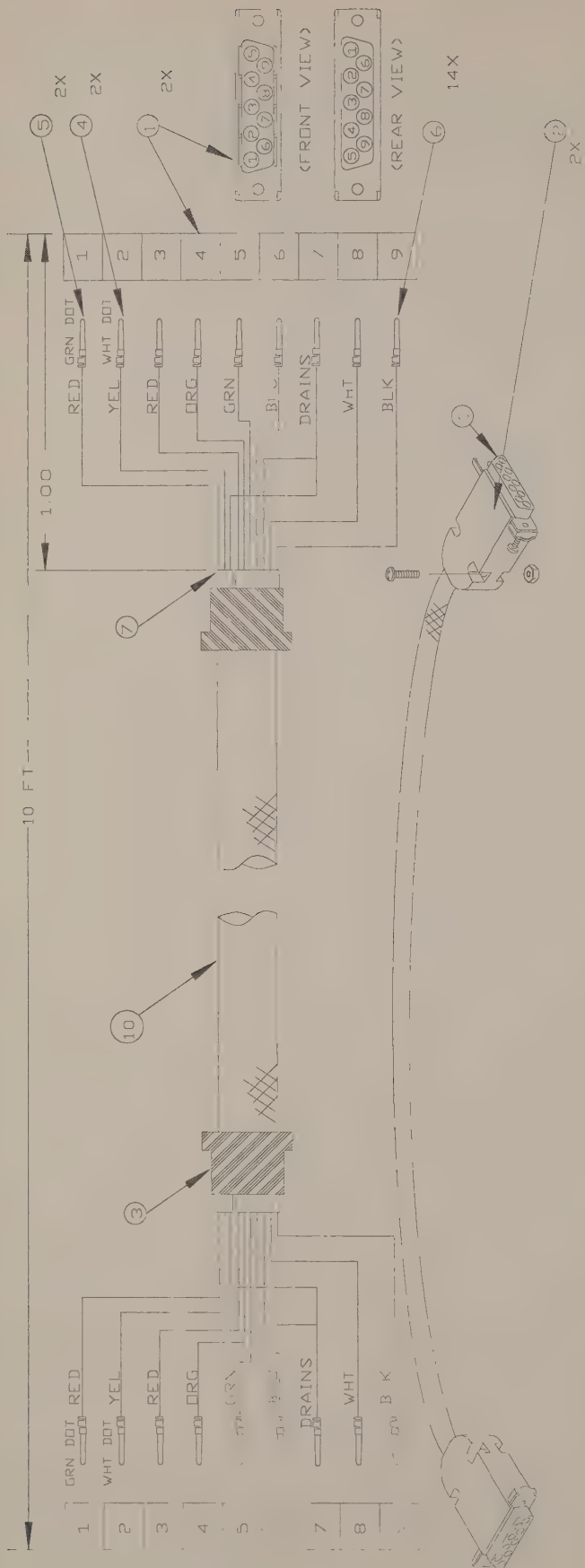
ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	12210073	AE210 PLUG, CABLE MOUNTING (ARRANGE 11-4)	EA		2
2	12210032	AE210 SHELL SIZE 11 AMP P/N 206062-1	EA		2
3	12210074	AE210 CONTACT, SOCKET, 16-18 AWG, F/CPC CONN.	EA		8
4	A1010505	AE600 CABLE, 4 COND., 16 AWG SHIELDED	FT	A	10
5	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE, 0.032x0.250 TAB	EA	A	1



CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - A

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1007544	AE210 CONN, 9 POS, D-SUB, RECEPTACLE W/O PINS	EA	A	2
2	A1007546	AE210 CONN, BACKSHELL, SIZE 9, D-SUB	EA	A	2
3	A1007580	AE210 GROMMET D-SUB BACKSHELL	EA	A	2
4	A1009830	AE210 CONTACT, TYPE K CHROMEGA (+) MALE	EA	A	2
5	A1009831	AE210 CONTACT, TYPE K ALOMEGA (-) MALE	EA	A	2
6	12210031	AE210 AE212 PIN, 20 AWG GOLD FLASH	EA		14
7	A1009827	OPX AE600 CABLE, SHIELDED TYPE K T/C 24 AWG	FT	A	10
9	A1010503	OPX AE600 CABLE, 6 COND., 24 AWG SHIELDED	FT	A	10
10	A1010506	OPX AE600 SLEEVING, WHITE EXPAND.POLYESTER 1/4" ID	FT	A	10



MICROMANIPULATOR
COMPANY, INC.
1555 Forrest Way
Carson City, Nevada 89706
Tel 702 / 882-7377
Fax 702 / 882-7694

PART TITLE

ASSEMBLY, RTD STYLE
T/C EXTENSION CABLE

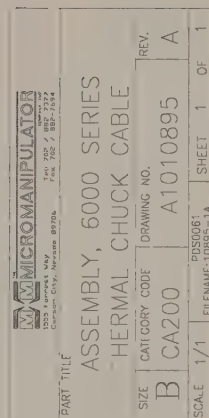
SIZE	CATEGORY CODE	DRAWING NO.	REV
A	CA200	A1010568	A

SCALE	NONE	FILENAME: PDS0011	SHEET	1	OF	1
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CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - B

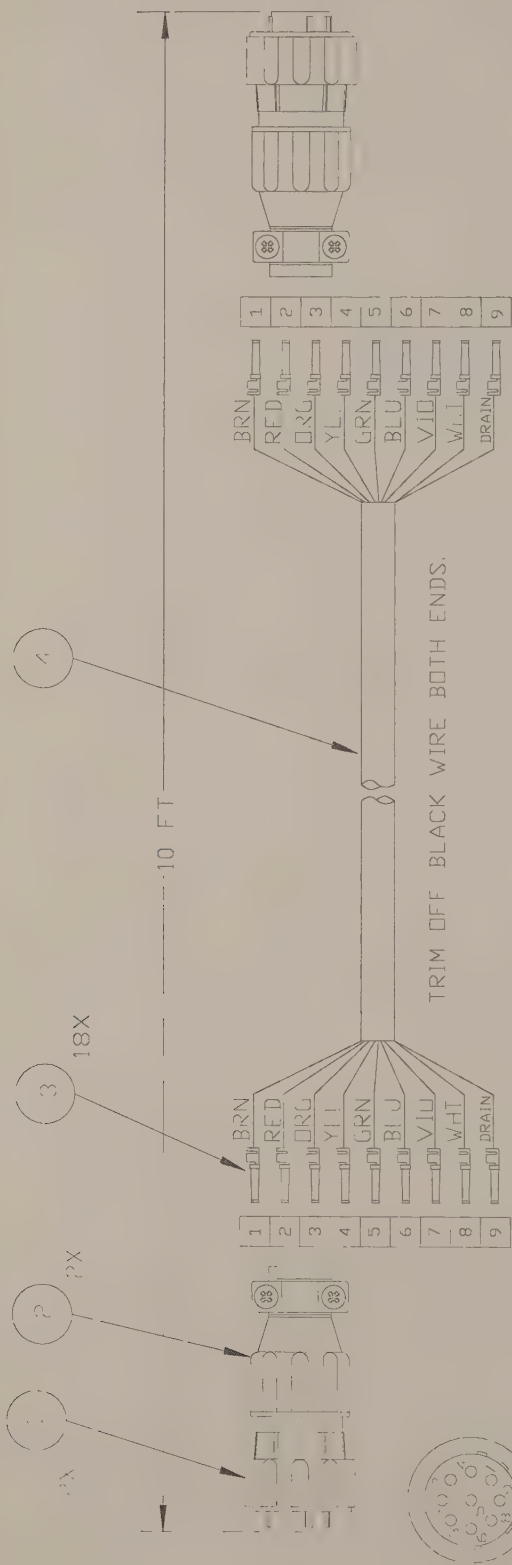
ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	12210087	AE210 PLUG, ARANG 17-16	EA		1
2	12210088	AE210 SHELL, SIZE 17 CABLE	EA	A	1
3	12210074	AE210 CONTACT, SOCKET, 16-18 AWG, F/CPC CONN.	EA		8
4	12210078	AE210 CONTACT SOCKET, 20-24 AWG, F/CPC CONNECTOR	EA		9
6	A1010505	AE600 CABLE, 4 COND., 16 AWG SHIELDED	FT	A	10
7	12210032	AE210 SHELL SIZE 11 AMP P/N 206062-1	EA		1
8	12210073	AE210 PLUG, CABLE MOUNTING (ARRANGE 11-4)	EA		1
9	A1007320	AE212 TERMINAL, SLIP-ON, FEMALE, 0.032x0.250 TAB	EA	A	1
10	A1010503	OPX AE600 CABLE, 6 COND., 24 AWG SHIELDED	FT	A	10
11	A1009827	OPX AE600 CABLE, SHIELDED TYPE K T/C 24 AWG	FT	A	10
12	A1010506	OPX AE600 SLEEVING, WHITE EXPAND. POLYESTER 1/4" ID	FT	A	11
13	A1007580	AE210 GROMMET D-SUB BACKSHELL	EA	A	1
14	A1007546	AE210 CONN, BACKSHELL, SIZE 9, D-SUB	EA	A	1
15	A1007544	AE210 CONN, 9 POS, D-SUB, RECEPTACLE W/O PINS	EA	A	1
16	A1009831	AE210 CONTACT, TYPE K ALOMEGA (-) MALE	EA	A	1
17	A1009830	AE210 CONTACT, TYPE K CHROME (A) MALE	EA	A	1
18	12210031	AE210 AE212 PIN, 20 AWG GOLD FLASH	EA		7



CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - A

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	12210025	AE210 PLUG, 9 SOCKET	EA		2
2	12210032	AE210 SHELL SIZE 11 AMP P/N 206062-1	EA		2
3	12210028	AE210 SOCKET, 20 GA. GOLD FLASH	EA		18
4	A1010608	AE600 CABLE, 9 COND. 24 AWG. SHIELDED	FT	A	10



MICROMANIPULATOR

1555 Carver Way
Carson City, Nevada 89706
Tel 702 / 488 2377
Fax 702 / 488 7694

PART TITLE

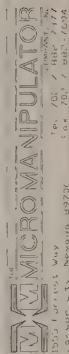
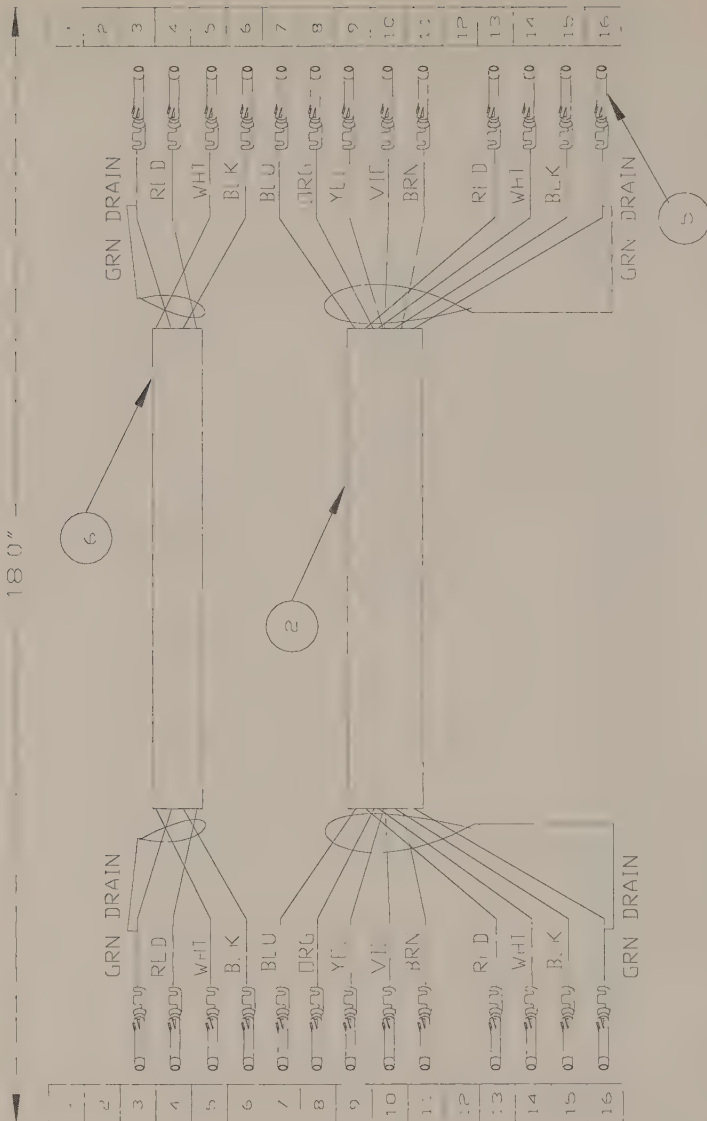
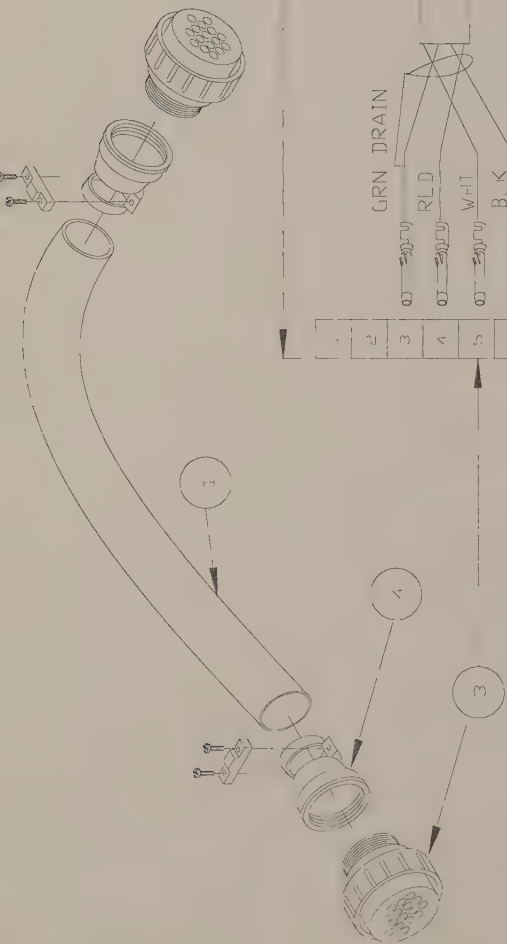
CABLE, SRV POWER

SIZE	CATEGORY CODE	DRAWING NO.	REV
A	CA200	A1010607	A
SCALE 1/1	P/N PDS0044	SHEET 1 OF 1	FILENAME: 10607-1A

CURRENT REVISION: A CURRENT ECN: DLH
NO PENDING ENGINEERING CHANGES

DRAWING SIZE - A

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010506	OPX AE600 SLEEVING, WHITE EXPAND.POLYESTER 1/4" ID	FT	A	2
2	A1010608	AE600 CABLE, 9 COND. 24 AWG. SHIELDED	FT	A	1.5
3	12210087	AE210 PLUG, ARANG 17-16	EA	2	1
4	12210088	AE210 SHELL, SIZE 17 CABLE	EA	A	2
5	12210078	AE210 CONTACT SOCKET, 20-24 AWG, F/CPC CONNECTOR	EA	26	1
6	A1010503	OPX AE600 CABLE, 6 COND., 24 AWG SHIELDED	FT	A	1.5



ASSEMBLY,

HEAT TO COOL MODULE CABLE

SIZE	CATEGORY CODE	DRAWING NO	REV
A	CA200	A1010565	A
SCALE 1/1	FILENAME 10565-1A	SHEET 1 OF 1	

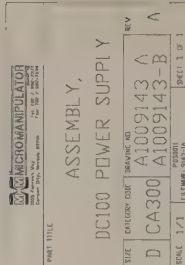
CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

CURRENT ECN: DLH

DRAWING SIZE - D

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1009137	AE390 1000 VOLTS/AMPS DC POWER SUPPLY	EA	A	1
2	A1009138	PSY PANEL, DC100 FRONT	EA	A	1
3	A1009139	PSY PANEL, DC100 REAR ACCESS	EA	A	1
4	A1009140	PSY MTG. EAR, DC100 LEFT & RIGHT SIDE	EA	A	2
5	12430049	AE430 RESISTOR, 1K 5% 1/4W CARBON COMP.	EA		1
6	12430074	AE430 RESISTOR, 10K 5% 1/4W CAR COM	EA		2
7	A1010504	AE600 CABLE, 2 COND, 16 AWG SHIELDED	FT	A	3
8	A1010506	OPX AE600 SLEEVING, WHITE EXPAND.POLYESTER 1/4" ID	FT	A	3
9	6004-0003-0	OPX AE600 CABLE, 2CNDR SHLD ALPHA 2254 BLDN 8737	FT		1.5
11	12600037	OPX AE600 CABLE, 22 AWG 10 WIRE GREY	FT		1.5
12	12210087	AE210 PLUG, ARANG 17-16	EA		2
13	12210088	AE210 SHELL, SIZE 17 CABLE	EA	A	2
14	12210074	AE210 CONTACT SOCKET, 16-18 AWG, F/CPC CONN.	EA		2
15	12210078	AE210 CONTACT SOCKET, 20-24 AWG, F/CPC CONNECTOR	EA		20
16	A1009827	OPX AE600 CABLE, SHIELDED TYPE K T/C 24 AWG	FT	A	2
17	A1008027	OPX AE600 CABLE, 4 COND, 24 AWG, SHIELDED BRAID	FT	A	1.5
18	A1008033	AE210 CONTACT SOCKET, 24-26 AWG, F/CPC CONNECTOR	EA	A	6
19	12600084	OPX AE600 TUBING, 1/2 BLACK SHRINK	FT		0.8333
20	12212018	AE212 RING, #6, 22-18 INSUL	EA		1
21	12600080	OPX AE600 TUBING, 3/32 SHRINK	FT		1
22	A1001350	AB700 PLUG, AMP CPC, KEYING	EA	B	2

REMOVE JUMPER BETWEEN (1) AND (2)
CONNECT RED WIRE TO POS1 IN (2)
CONNECT SHIELD AND BLACK WIRE TO (2)



CURRENT REVISION: A
NO PENDING ENGINEERING CHANGES

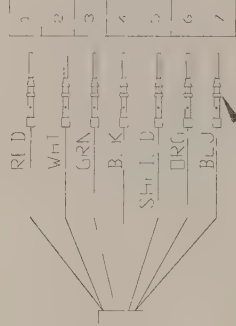
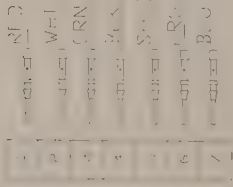
CURRENT ECN: DLH

DRAWING SIZE - A

ITEM	PART NUMBER	DESCRIPTION	U/M	REV	REQ'D
1	A1010503	OPX AE600 CABLE, 6 COND., 24 AWG SHIELDED	FT	A	10
2	12210033	AE210 CONNECTOR, POWER PLUG-VIKING TKP07-100	EA		2
3	12210029	AE210 SOCKET, GOLD PLATE VIKING# TS-100	EA		14

FRONT FACE

10 F 1



A1010503 1

14X
12210029 3

12210033 2X



COMPANY, INC.
1555 Forrest Way
Corson City, Nevada 89706

Tel 702 / 882-7100
Fax 702 / 882-7694

PART TITLE

CABLE, H100-RS232
MODULE TO CONTROLLER

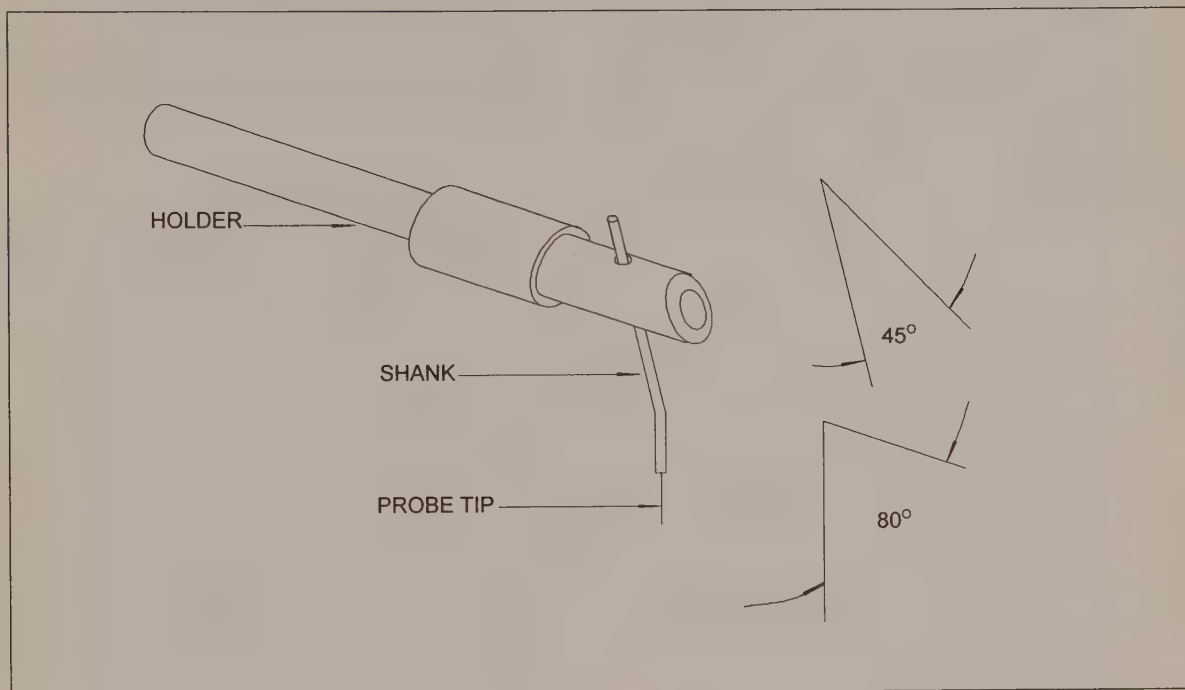
SIZE	CATEGORY CODE	DRAWING NO	REV
A	CA200	A1008947	A

SCALE 1/1 P\N FILENAME 8947-1A SHEET 1 OF 1

APPENDIX D
APPLICATION NOTES

Hot Stage Probing Technique

A pplication N ote



Abstract

When using a hot stage for elevated temperature probing or CV measurement, there will be movement of a device under the probe and the probe point due to thermal expansion. This uncontrolled movement may be enough to cause the probe to slide or jump off its contact. On a six or eight-inch wafer, the expansion can result in a movement of up to one mil at any location, in some unpredictable direction, for every 100° C temperature change.

This Application Note discusses the causes and effects of this problem and offers an equipment solution.

The Key

A high compliance probe point, like our model 7F, will follow a target device as it moves in the X,Y,Z axes. The 7F probe has a very fine wire tip that flexes. When using it with a small amount of flexure on the tip and at a near vertical angle of about $80^\circ \pm 5^\circ$, it is steep enough for this application, while it remains visible under a microscope.



Micromanipulator

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At The Micromanipulator Company, we take pride in manufacturing the finest equipment available for probing small geometries. We also spend considerable energy trying to solve application problems. Here is an extensively researched solution to a relatively common probing dilemma:

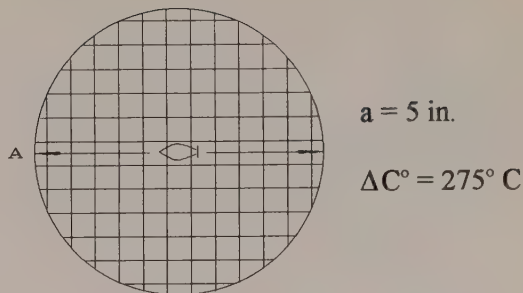
Maintaining probe contact during temperature stressing of wafers can compound the natural difficulties already associated with probing.

This is due mostly to the relative motion between the fixed probe connected to the manipulator and the desired probe site on the wafer. The relative motion is due to the effects of thermal expansion of materials when heated and/ or converse contraction when cooled. Since these motions occur in all dimensional axes, operators may encounter different perspectives on different probing problems.

Let's first discuss the coefficient of thermal expansion for silicon which is 2.8 uin/ in. °F.⁽¹⁾ This equation can be permuted into several easier-to-work-with equations by using dimensional analysis (conversion factors). Here are several permutations that allow us to determine relative motion based on the most convenient units available for consideration.⁽²⁾

1. 2.8 uin/in. °F or 0.071 μm/in. °F
2. 2.8 uin/2.54 cm °F or 0.071 μm/2.54 cm °F
3. (1.8) 2.8 uin/in (Δ°C) or
(1.8) 0.071 μm/in. (Δ°C)
4. (1.8) 2.8 uin/2.54 cm (Δ°C) or
(1.8) 0.071 μm/2.54 cm (Δ°C)

With this information, let's determine the anticipated expansion between two points on opposite edges of a five-inch diameter wafer that is heated from 25°C to 300°C.



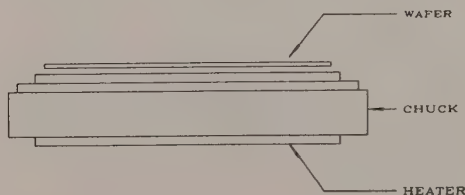
$$(1.8) 2.8 \text{ uin/in. } (\Delta^\circ\text{C}) \text{ or } (1.8) 0.071 \mu\text{m/in. } (\Delta^\circ\text{C}) \times 5 \text{ in. } 275 \Delta^\circ\text{C}$$

$$[(1.8) 0.071 \mu\text{m}] \times 5 \times 275 = 175.73$$

We can expect a 176 micron expansion of this entire wafer's diameter. Since materials tend to expand linearly from the center and if the heating effect is homogeneous and the material unrestrained, we could say that from the center of this same wafer to either point, we should expect approximately 88 microns of expansion. This alone will establish us with our relative motion between the fixed probe and the probe site. Experience suggests that this movement occurs but not always in a predictable direction due to other influences such as stage vacuum (or lack of it), back side contact, special friction points, and the thermal effects of the stage itself.

Silicon has a considerably smaller coefficient of thermal expansion than most pure metals and metal alloys. Consequently, heat stage design, construction, and wear can result in even greater apparent motions than the effect of the silicon itself.

Stage planarity, thickness, and construction can also create great problems with motions in the Z-dimension as well as X and Y-axes of travel.



Take, for example, a heat stage design which is a quarter of an inch thick slice of aluminum sitting on top of a heater.

Place your wafer on this hot stage and heat it from 25°C to 300°C. Disregarding the wafer thickness and assuming perfect planarity of the stage surface, how much motion upwards (Z) would you expect the wafer to travel? The coefficient of thermal expansion for aluminum is 14 uin/ in. °F ⁽³⁾ or (1.8) 0.356 μm/in. (Δ°C).

Since the aluminum sits on the heater, the aluminum will push the wafer up (0.250 in. 275 °C) or a minimum of 44 microns toward or into the probe contact area. [1.8 (.356 μm/ in (Δ °C) x .250 in x 275 Δ °C = 44.055 μm].

It should be apparent that the Z-motion effects of the stage, if not compensated for, have a greater consequence with respect to relative motion of the wafer and the probe point than the XY motion. If the hot stage planarity with respect to the probing plane was skewed, then the effects of thermal expansion would even further exacerbate this problem.

Hysteresis, which can be described as the retardation of the effect when the forces acting on a body are changed⁽⁴⁾, can make it impossible to predict where probe sites might end up after the completion of a cycle of heating and cooling. Therefore realignment of probes could be required when simply raising the probes during a heat cycle to avoid all the aforementioned motion problems.

Ignoring the obvious desire to compare our hot stage construction with other manufacturers' designs, it is believed that the problem is best solved by the use of an extremely compliant probe tip.

What is meant by compliant probe tip is one that will flex as a spring flexes when a very small force is applied. Naturally, the least force required for this spring action would minimize the possibility of damage to the wafer.

The requirements for qualifying such a probe or probe tip can be first determined empirically using formulas for establishing the stability of elastic columns. Although these engineering formulas are normally used to qualify parameters of design opposite to this concern, they produce valid data for these purposes.

Using Euler's formula for pin-ended columns, we can qualify the criteria that makes one probe tip better than another. Euler's formula for pin-ended columns is

$$P_{\alpha_2} = \frac{\pi^2 EI^{(5)}}{L_e}$$

where

P_{α} = the critical load that will cause bending.

E = modules of elasticity; for tungsten is 50X10⁶ PSI. ⁽⁶⁾

I = moment of inertia; moment of inertia for a solid round-section column is

$$I = \frac{\pi d^4}{64}^{(7)}$$

d = diameter of a circle.

L = length of column.

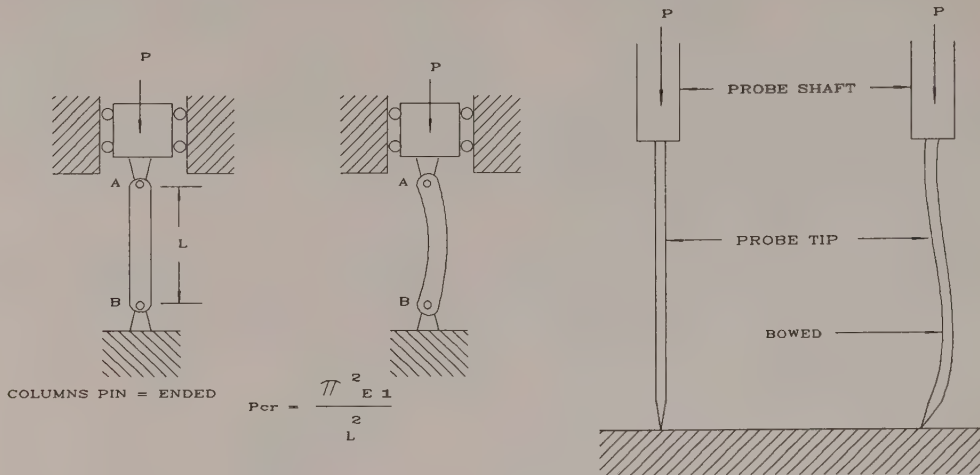
L_e = effective length of column.

Thus, our working Euler's formula is:

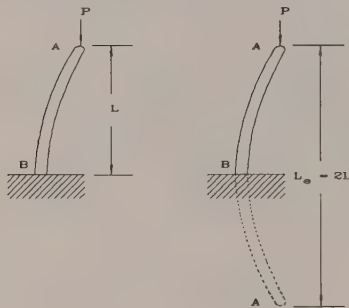
$$P_{\alpha} = \frac{(\pi^2) E \left(\frac{\pi d^4}{64} \right)}{L_e^2}$$

$$\text{or} \quad \frac{\pi^2 (50 \times 10^6 \text{ lbs/ins.}) \left(\frac{\pi d^4}{64} \right)}{L_e^2}$$

Here are illustrations of the theoretical pinned-end column and of a theoretical probe on a wafer:



The similarities should be readily apparent in this example. Our probe tip on a wafer is actually closer to an extension of Euler's formula for the column with one fixed end and one free end.



In this condition, the column will behave as the upper half of a pin-connected column and therefore the effective length (L_e) is equal to twice the length of the column, that is, $L_e = 2L$. This permutes Euler's equation for our probe to be:

$$P_{cr} = \frac{(\pi^2) EI^{(8)}}{(2L)^2}$$

$$P_{cr} = \frac{\pi^2 (50 \times 10^6 \text{ lb/in}^2) (\frac{\pi d^4}{64})}{(2L)^2}$$

This equation further illustrates that the criteria of the columns that we are interested in are its length and diameter. P_{cr} is directly proportional to the diameter of the column/probe and indirectly proportional to its length, that is $P_{cr} \propto \frac{d}{L}$.

In the previous illustration, the tips have been scaled 50 times larger than normal so that two distinct (if not three) features can be rapidly distinguished, that is, length and diameter. When we fit these numbers in the Euler equations, we can see that maximum forces might be applied when bending or bowing these probe tips. Remember, the pressure exerted on the wafer rapidly drops after bowing occurs and that the probe tip operates like a spring.

Again we repeat the formula:

$$P_{cr} = \frac{(\pi^2) EI^{(8)}}{(2L)^2}$$

$$P_{cr} = \frac{\pi^2 (50 \times 10^6 \text{ lb/in}^2) (\frac{\pi d^4}{64})}{(2L)^2}$$

When we solve P_{cr} for the 7A probe whose $L=.130$ in. and $d=.0005$ in. we find that a maximum of 0.224 lbs (101.6 gr) force may be applied prior to its bowing.

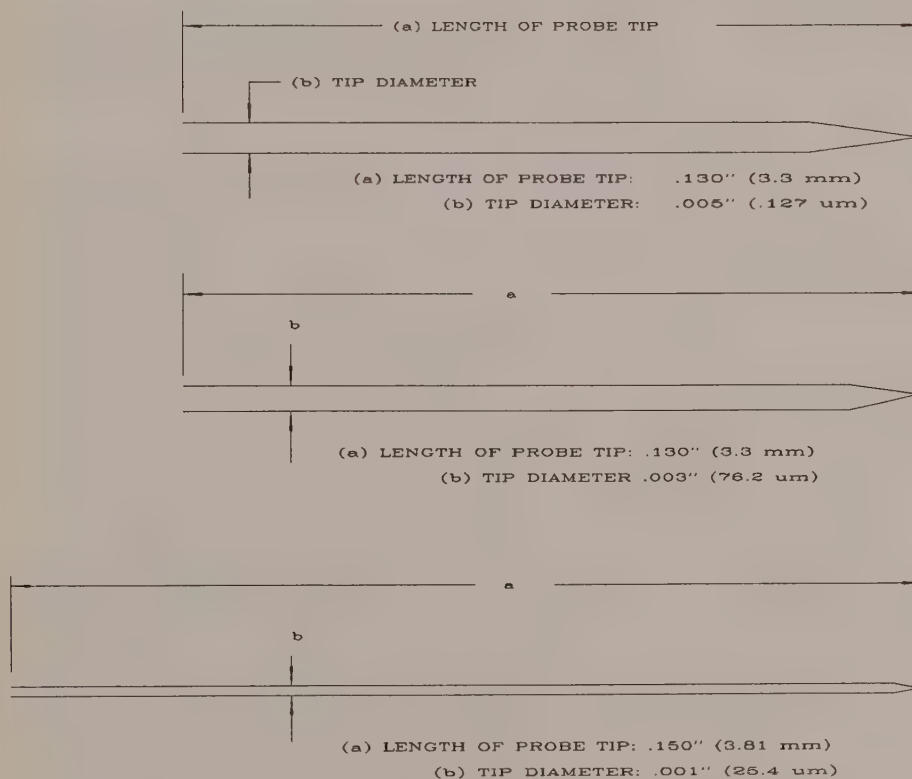
The 7X whose $L=.130$ and $d=.0003$ in. may require a maximum for of 0.029 lbs x (13.17 gr) to initiate bowing.

Lastly, the 7F probe whose $L=.150$ in and $d=.001$ in. may require a maximum force of 0.000269 lbs (0.12 gr) to initiate its bowing.

We recommend the 7F probe for use in thermal cycling situations. Since it requires only a small amount of force to initiate bowing (approximately

1/10 of a gram), X, Y, or Z-motion of the wafer probe site can be easily compensated for by maintaining constant probe contact during a heat cycle.

This flexible probe concept has been found to be one of the safest ways to probe on very thin oxide sites regardless of thermal cycling. Experience with certain thin oxides has demonstrated that no damage occurs when vertically probing with the model 7F. Other probes invariably damaged the oxide. CV measurements of inversion can be used to verify our findings concerning oxide damage, etc.



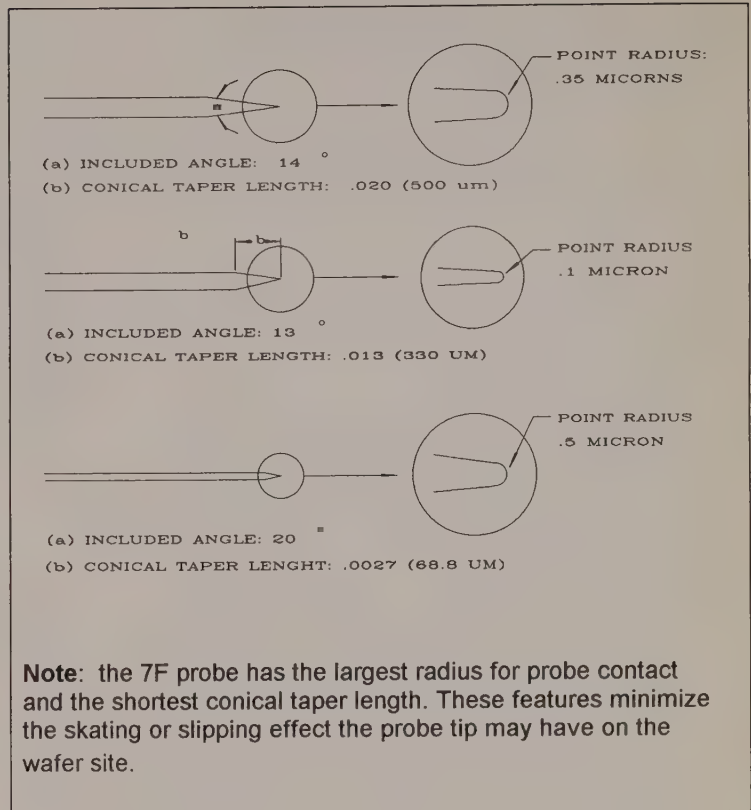
Note: the following illustrations which compare three different probe tips available in our Model 7 series of disposable probes. They are the 7A, 7X and the 7F probe tips.

The third feature of the earlier illustration that may have gone unnoticed is the conical taper length of the three different probe tips. The next illustration magnifies those portions of the probe tips for further comparison.

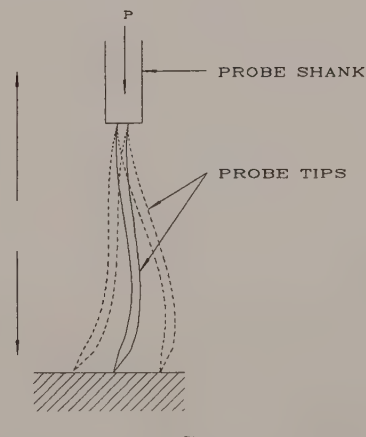
A probe angle of about 80° plus or minus 5° is sufficient to produce a good probe point contact and flexure. While the more vertical the probe point flexes more easily, many people will desire this slight angle for ease in viewing under a microscope.

As with all forms of probing small geometries, a little technique can go a long way, and each operator will find the most suitable probing angle and/or technique if these simple guidelines are followed:

1. Probe as close to vertical as possible.
2. Use of 7F style probe tip. (Very small diameter with as long a length as possible.)
3. When making probe contact, continue lowering the probe until bowing or flexure of probe tip is seen.
4. Verify bowing by using a little X or Y-motion of manipulator or stage and insure probe contact follows the motion and stays on target site.
5. Practice makes better.

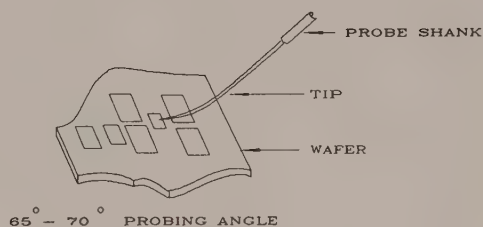
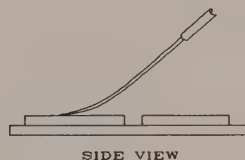
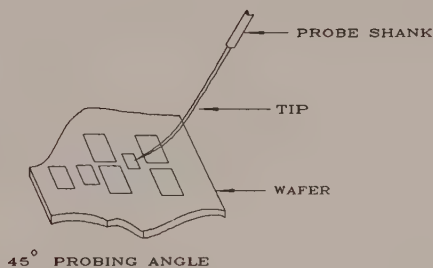
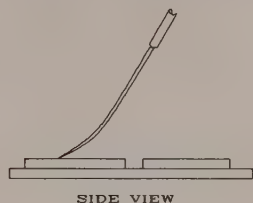


Flexible Probe Concept



(as the pad moves, the probe tips moves with it)

Probing as close to vertical as possible is necessary or the probe tip tends to skate off of the probe site rather than flex with the target.

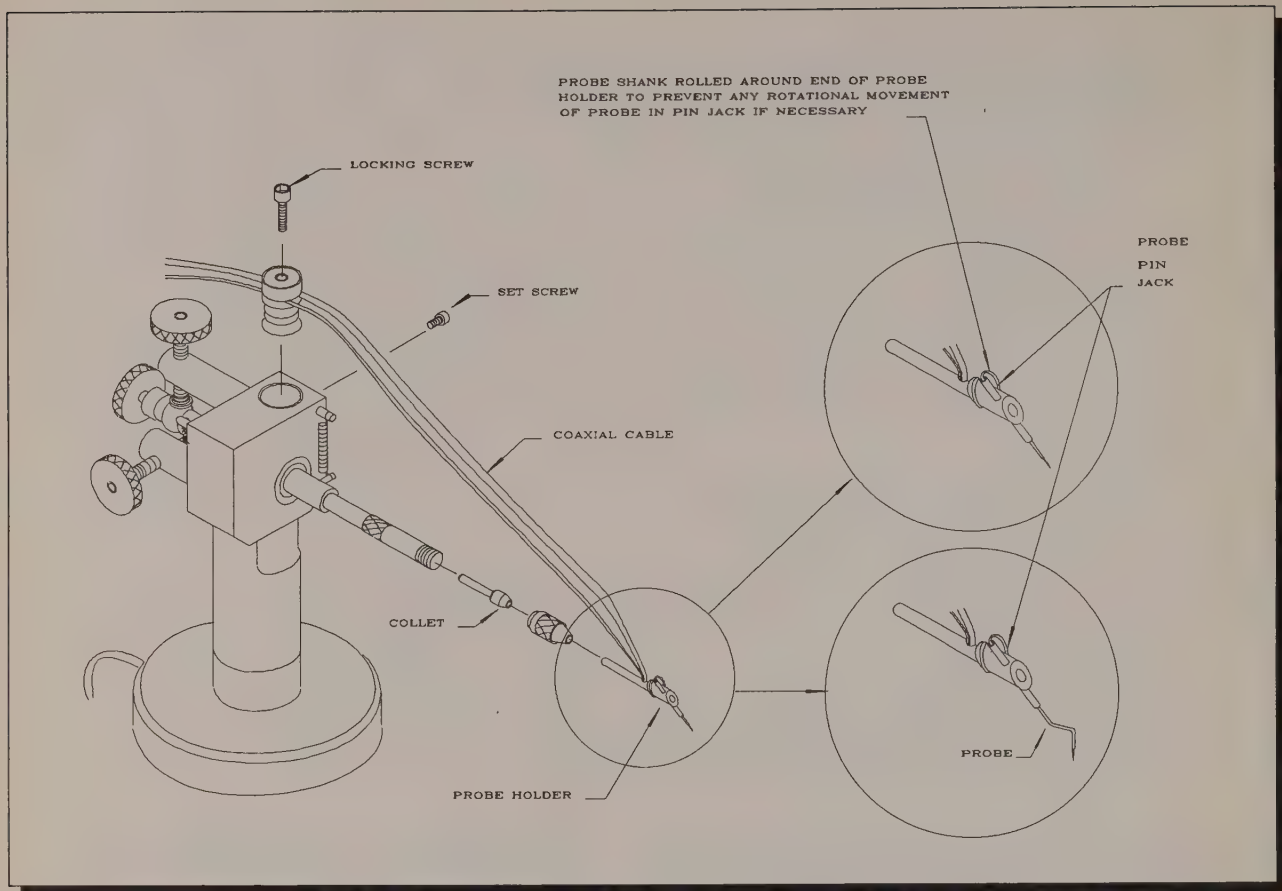


The following provides guidelines for using a Model 79 (coaxial probe holder) with a 7F probe and an open style manipulator. The basics to note are:

1. All probe holders use a Model 5 collet for probe to manipulator electrical isolation.
2. Cable strain reliefs are recommended with probe holders that use large or bulky cables. Strain reliefs for both open and closed style manipulators are part of an accessories package that can be purchased from the Micromanipulator Co., Inc. (Part #19107017).
3. Placement of probe tip into probe holder. We recommend as vertical a probing arrangement as practical for the operator.

4. When using a Model 79 probe holder as illustrated, we recommend rolling the extra length of probe shank around the tip of the holder to prevent any probe rotation in the pin jack.

The newer Model 79-02 probe holders are equipped with a higher spring force pin jack and Model 79-03 probe holders use a small locking screw to prevent probe rotation.



End Notes

¹Ray E. Bolz and George L. Tuve, ed., CRC Handbook of Tables for Applied Engineering Science, 2nd ed. (Boca Raton, FL: CRC Press, Inc., 1970-73) pp. 117.

²Ibid, pp. 817-847.

Conversions for dimension analysis used;

1 m = 39.370079 in

1 in = 0.0254 m

1 in = 2.54 cm

1 μ m = 10^{-6} m

Absolute zero:

on Celsius scale is -273.15°C

on Fahrenheit scale is -459.67°F

$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$ $^{\circ}\text{F} = 9/5 (^{\circ}\text{C}) + 32$

³Ibid, pp. 117.

⁴Webster's New Collegiate Dictionary, 1961 ed.

⁵Ferdinand P. Beer and E. Russell Johnston Sr., Mechanics of Materials (New York: McGraw-Hill Book Co., 1981), pp. 526-534.

⁶Bolz, CRC Handbook of Tables, pp. 117.

⁷Joseph Edward Shigley and Larry D. Mitchell, Mechanical Engineering Design, 4th ed. (New York: McGraw-Hill Book Co., 1983), pp. 148-154.

⁸Beer, Mechanics of Materials, pp. 531.

Model 8800 Series Tempseal and Dryer System

Application Note

The **8800-TEMPSEAL** option for Micromanipulator's 8800 series probers (8060, 8065 and 8860) provides a dry environment in which low temperature probing may be accomplished with no condensation or 'frost' formation on the test device, system chuck, or the prober stage drive.

Samples may be probed to temperatures of **-65 degrees C** in an environment using probe cards, individual probes, or a combination of both.

The **8800-TEMPSEAL** maintains the prober chuck surface and sample in a dry condition. In addition, it also maintains the stage drive and chuck plumbing system in a dry state. This is not currently available in other dry probing system and offers the distinct benefits of reducing problems due to:

- * Condensation at the sample edges to cause shorting or unpredictable effects.
- * Condensation on the stage drive system which interferes with stage accuracy and repeatability.
- * Condensation on the chuck plumbing cables and hoses causing wear and possible shortage or breakage.
- * Reduced residual moisture contaminating the prober internal drive system and causing reliability / life problems or leaking underneath or around the prober.

Tempseal and Dryer System

The **8800-TEMPSEAL** provides an enclosure which extends from underneath the prober base to the probe station platen. The enclosure width is that of the platen itself, thus resulting in no increase in size to the probe station footprint. The **8800-TEMPSEAL** enclosure houses the probe station stage drive system, the wafer chuck (or other sample holder), and the internal plumbing cables and hoses for the hot/cold chuck. The internal plumbing cables and hoses are connected via an interface/feedthrough panel on the rear of the probe station. Provided by the user or with the Micromanipulator model **8800-DRY-VO** air drying system, dry air is introduced to the **8800-TEMPSEAL** from the rear of the probe station, and from a ring above the chuck surface to insure a low level of internal positive pressure and maintain a dry environment.

Access to the **8800-TEMPSEAL** is provided via a removable front platen "wedge" for sample loading and unloading, via a rear port for probe card cables and via sample covers which provide access for the prober microscope objectives and individual probes, as required.



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Fax: 702/882-7694

Typical Application with TEMPSEAL and 8800-DRY:

1. Position probe card and/or individual probes as required using **8800-TEMPSEAL** sample cover. Use the cover with the fewest number of access ports for best results.
2. Load sample onto wafer chuck, center chuck position, and replace **8800-TEMPSEAL** loading platen wedge, closing **8800-TEMPSEAL** environment.
3. Turn on the **8800-DRY-VO** system with input pressure 80-100 PSIG and set output flow to 5-7 CFM. **Note:** Air dryness decreases significantly with reduced input pressure. For example, with 50 PSIG input pressure, the dewpoint at the sample environment is typically -10 to -15°C. Increases in air flow rates will not significantly alter the environment dewpoint but may instead cause undesirable turbulence.
4. Keep hot/cold chuck controller off for purge. (Some chucks maintain a cold flow to parts of the chuck at all times, therefore purge times will be reduced if the environment is purged with the chuck controller off).
5. Purge environment. Purge time will vary with the desired temperature, ambient humidity, and input pressure to dryer. Also, purge time must be determined empirically for a particular application. For example, a typical purge time of 30-40 minutes is usually adequate for -40° C probing.
6. Turn on chuck controller and elevate temperature (typically to 100° C) for 5 to 10 minutes to drive off residual chuck moisture.
7. Chuck temperature may now be set to the cold probing temperature and the dry environment will be maintained.

Specifications

8800-TEMPSEAL

Availability: For model 8060, 8065, and 8860, 6 or 8 inch probing stations.

Environment maintained: Prober chuck, stage drive, and internal plumbing are maintained in the dry environment.

Physical configuration: Fully contained within the standard probe station physical "envelope." No increase in probe station space occupied is realized.

Dry temperature range: To -65 degrees C (depends upon dewpoint of incoming air provided by user or with Micromanipulator model 8800-DRY-VO air dryer/filter system).

Application: May be used with probe cards only, with individual manipulators and probes (manual or programmable) or a combination of both.

8800-DRY-VO

Electrical:

110/240 volts AC, 50/60 Hz

Physical Dimensions:

With castors provided, 13" (33 cm) deep, 30.4" (76 cm) wide, 40" (99 cm) tall

Input Air:

80-100 PSIG recommended for -65° C probing with 8800-TEMPSEAL

Output Flow:

0 to 20 SCFM (5 to 7 SCFM recommended with 8800-TEMPSEAL)

Output Air:

- * Oil vapor and Hydrocarbon removal to 0.5 to 2.0 PPM
- * Particulates filtered to 0.3 micron with 99.97% DOP efficiency
- * Dewpoint to -100° F (-73.3° C), with 100 PSIG input pressure

Model HS-HE Self-contained Heat Exchanger

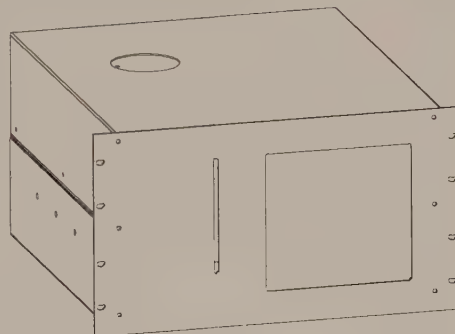
Specifications

The Model HS-HE heat exchanger is the answer for H1000 Thermal Chuck Systems that require self-contained cooling down to room temperature.

The heat exchanger is available as part of the cooling option or separately to upgrade systems that use customer supplied water and drain.

Features and Benefits

- Self-contained system eliminates the need for a water supply and drain in ambient cooling options.
- Fully compatible with the C1000 cooling module which controls heat exchanger operation.
- Equipped with self-sealing quick disconnect plumbing with internal shutoffs to prevent fluid spills.
- High reliability copper core heat exchanger provides ample 1200 Watt cooling capacity to provide rapid cool down from 400 degrees C to ambient temperature.
- Contains a sight gauge on the front panel to easily monitor the fluid level.
- Available in both 110 VAC or 220 VAC configurations with external power switch, fuse and detachable line cord.
- Integral containment pan with safety drain provided for accidental fluid leaks.
- Optional 19" rack mount kit is available. Requires 10.5" rack space in a 25" deep cabinet.



Shown with HE-19 Rack-Mount Configuration

Specifications:

Physical dimensions:

17" wide, 10.5" high, 20" deep

Facility requirements:

Power:

HS-HE-V1 115 VAC; 3A
HS-HE-V2 220 VAC; 1.5A

Shop air:

10-65 psig

Cooling fluid:

Type: De-ionized or distilled water
Capacity: 2.5 gallons

Space:

Allow at least 12" in front of unit for air circulation

Accessories:

HE-19-KIT 19" Rack Mount Kit

Ordering information:

HS-HE-V1 Heat exchanger, 110 VAC
HS-HE-V2 Heat exchanger, 220 VAC

The HS-HE heat exchanger is included in these H1000 cooling options:

C1000-V1-HE
C1000-V2-HE

H1000 Series

High Performance Thermal Chuck Systems



Thermal Chuck shown with AC controller

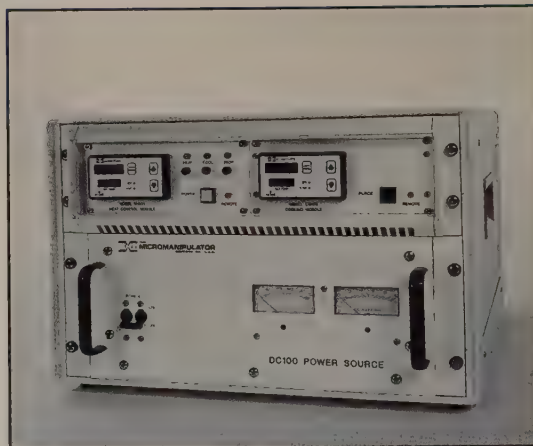
Specifically Designed for Use with Probing Stations and Featuring

- ▶ **Super Low Noise Performance**
- ▶ **Low Capacitance**
- ▶ **High Isolation**
- ▶ **Fast Cycling Times**
- ▶ **Superior Temperature Uniformity**
- ▶ **Modular Configurations**

Design Concept

The H1000 series of thermal chucks was designed from over 40 years of probing experience. The result is a thermal chuck SYSTEM that integrates into the probing environment to provide not only sample thermal control, but one that maintains the accuracy and functionality of the probing station itself. This approach is evident in features such as:

- **External Cooling Shield.** Presents a cool surface around the chuck to minimize personnel burns and prevents transfer of the chuck heat to the probe station stage drive thus maintaining positioning accuracy, repeatability and enhancing the reliability of the stage drive itself in both manual and programmable systems.
- **Plumbing Service Module.** External to the thermal chuck controller, this module routes the flow of coolant outside of the main controller rack removing the danger of coolant leaks on sensitive equipment in a rack mounted controller.
- **Quick Disconnects.** Hoses carrying cooling fluid feature self sealing quick disconnects to prevent fluid leakage and its associated inconvenience when disconnecting the chuck from the controller (or the probe station with Micromanipulator stations).



DC Controller

Chuck SYSTEMS, Not Components

The highest performance is obtained from a thermal chuck designed as a system instead of a series of components "added-on" to each other. The H1000 thermal chucks feature:

- **Integrated Conductive and Isolating Layers** in both coaxial, advanced coaxial and triaxial chucks which maximize heat transfer and uniformity while still providing high performance electrical characteristics.
- **Kinematic Mounting** which places the hot chuck thermal surface on a dynamic mount that actually minimizes vertical expansion into the probes or probe card.
- **Cast-in Heating and Cooling Elements** provide for rapid temperature cycling as well as the best temperature uniformity in the industry.



Thermal Chuck

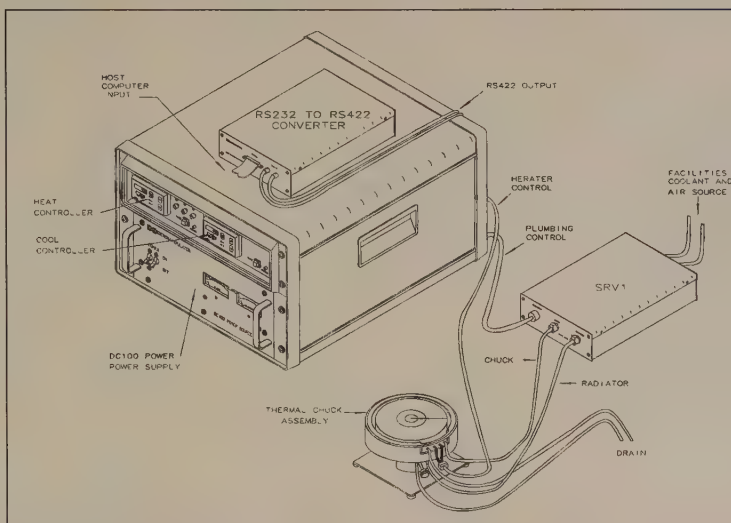
Configurations to Match Your Application

Configure the thermal chuck system to fit your needs including choices of:

- Hot only
- Hot and Cold
- DC driven (low noise)
- AC driven (economical)
- Coaxial chucks (4", 6", 8")
- Triaxial chucks (4", 6", 8")
- Advanced Coaxial chucks (4", 6", 8")

Product Configurator

Configure your H1000 series thermal chuck system from the following choices:



1. Start with a Heating Controller and Power Supply type

H1000-DC1-V1 (V2)
DC -PID power supply

H1000-AC1-V1 (V2)
AC (zero crossing or burst firing) PID power supply

2. Choose a Computer Interface

The native RS-422 interface to both the heat and cooling modules can be used with either RS-232 or IEEE-488 interfaces (not required for manual operation).

H1000-RS-232
H1000-RS-422
H1000-IEEE

3. Choose a Cooling Option

(options include SRV1 service module)

Chuck may be operated without a cooling option if air cool is acceptable for your application.

C1000-V0-H
Ambient to 400° C
(water supply and drain
must be supplied)

C1000-V1(V2)-HE
Ambient to 400° C
(includes self-contained
heat exchanger)

C1000-V1(V2)-C-0
0° C to 400° C
(includes refrigeration system)

Note: For cooling to -65° C, see integrated -65° C to + 400° C system on page 8.

4. Choose a Chuck Configuration

CHK6000-6C (or 4C)
4" or 6" coaxial chuck for
6000 series stations

CHK6000-6XC (or 4XC)
4" or 6" advanced coaxial chuck
for 6000 series stations

CHK6000-6T (or 4T)
4" or 6" triaxial chuck for
6000 series stations

CHK8800-8C (or 4C or 6C)
4", 6" or 8" coaxial chuck
for 8000 series stations

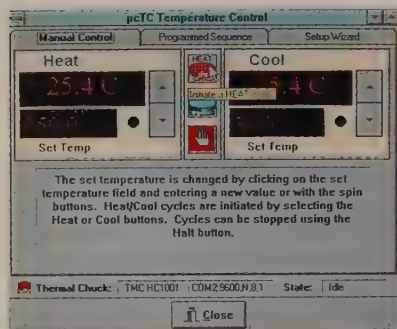
CHK8800-8XC (or 4XC or 6XC)
4", 6" or 8" advanced coaxial
chuck for 8000 series stations

CHK8800-8T (or 4T or 6T)
4", 6" or 8" triaxial chuck
for 8000 series stations

Adapters for other probe station manufacturer's products are available. The above items may also be ordered with lift pins (LFT) for use with auto loaders.

pcTC™ Thermal Chuck Control Software

Micromanipulator's pcTC™ Thermal Chuck Control program is a Microsoft Windows™ based, user friendly, graphically based interface program which will allow the control of a variety of thermal chuck systems including those produced by Micromanipulator. The program features common function icons and set point adjust windows for easy set up of heat, soak and cool programs as well as event notification to other concurrently running programs.



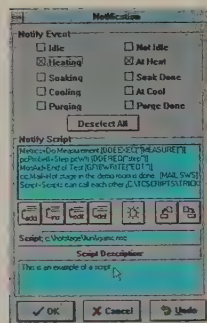
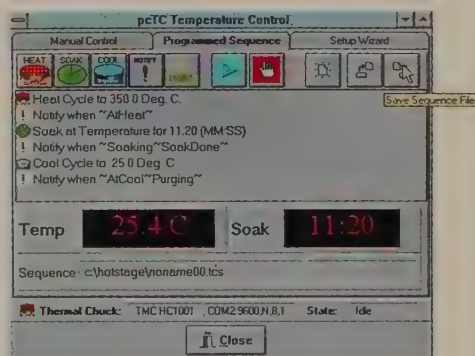
Manual Set Up

Manual Set Up mode allows easy control of temperature set points in heat or cool modes. Dial in the temperature desired, then activate the heat or cool cycle. Cycles may be stopped at any time.

Programming a Sequence

Programming a sequence is as easy as selecting the function icon, setting the parameters and clicking OK.

Heat, Soak and Cool events may be programmed with external program event notification. Sequence files may be saved and recalled for later use.



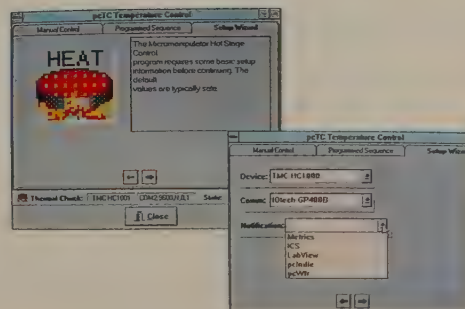
Notification

Notifications to other programs is easy using either common event notification check boxes or the flexible script editor.

Notification may be made via DDE, RS-232 or IEEE-488 (requires National Instruments GPIB Interface in pcTC computer for IEEE-488 operation).

Setup Wizard

pcTC also provides a Setup Wizard for configuring your system. Select the device (Thermal Chuck type, Micromanipulator or other manufacturer) to be controlled, the communications interface to be used, or Windows programs to be notified from the easy wizard-led routine.



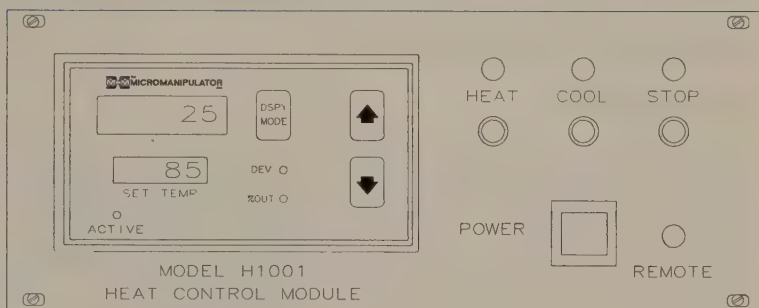
The H1000 Controllers

All H1000 controllers feature PID (Proportional, Integral, Derivative) control. This method of control has three operational modes operating in conjunction with each other to provide optimum performance in dampening of system response (**P**), correction for droop between set point and actual process temperature (**I**), and anticipation of set point approach to minimize over and under shoot (**D**). The PID algorithms have been tuned to provide maximum efficiency, cycle speed and control accuracy over the thermal chuck system range of temperature.

Heating Systems:

The **H1000-DC1-V1 (V2)** Controller features a LINEAR DC power system.

PID control maximizes ramp speed and accuracy while the DC operation coupled with the high electrical isolation of a H1000 series hot chuck provides a thermal chuck system with noise levels as low as 1 fA in the guarded, triaxial mode.

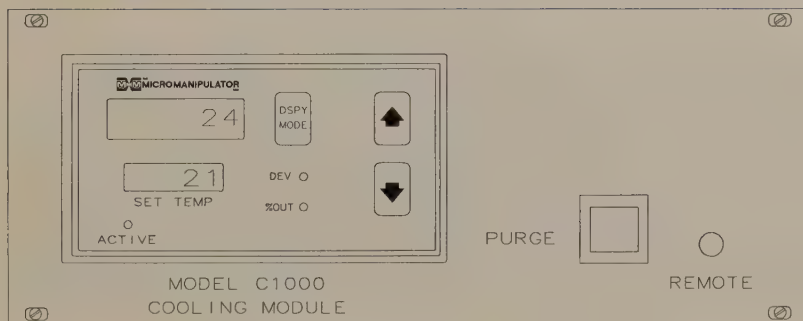


The **H1000-AC1-V1 (V2)** Controller features a PID drive which uses AC power (sine wave). The AC power is applied at the "Zero Crossing" point to minimize noise spikes due to abrupt changes in the drive signal. The result is a very electrically quiet and efficient drive signal to the chuck. For applications where the chuck may be grounded, the AC drive is electrically quiet enough for the most demanding applications.

Isolation Relays

Both H1000 controllers feature Isolation Relays. The Isolation Relays in the H1000-AC1-V1 ensure that all AC voltage is removed when the controller is not in heat mode.

Cooling Modules:



The **C1000-V0-H** and **C1000-V1(V2)-HE** cooling options provide fast cool down of the thermal chuck. Temperature control is provided by the heat controller when in heat mode. The C1000-V1(V2)-C-0 provides fast cool down of the thermal chuck as well as temperature control to 0° C.

Cooling modules receive power from the H1000 heat modules and operate in conjunction with those controllers to provide operation over the full system temperature range. Automatic purging after cool down is provided with the ambient cooling options. The zero degree cooling option provides automatic purging when the chuck temperature rises 1.5° C above the cool set point temperature. Manual purging is available with all cooling options.

Controller Safety Features

All H1000 controllers feature state-of-the-art safety features including:

- Over-temperature protection.
- Thermocouple failure runaway protection, including a **secondary controller with its own temperature sensor**.
- In addition, a service module and self-sealing quick hose disconnects are provided with cooling modules for routing and control of coolant remotely from controller system minimizing the chance of fluid leakage into the system electronics.

Controller Specifications

Heating Controllers

Function	H1000-DC1-V1	H1000-AC1-V1
Control Method	PID, DC Power	PID, Zero Crossing, AC Power
Temperature Range	Ambient to 400 degrees	Ambient to 400 degrees
Temperature Resolution	0.1 deg C	0.1 deg C
Temperature Stability	0.1 deg C	0.1 deg C
Over-temperature Protection	Max +25 deg C	Max +25 deg C
Status Indicators	Heating Fault % Deviation % Power Applied	Heating Fault % Deviation % Power Applied
Computer Control (Optional)	RS-232, RS-422, IEEE-488	RS-232, RS-422, IEEE-488
Operational Modes	Manual or Computer Control	Manual or Computer Control

For more information, see Heat Controller specification sheet A1011205.

Cooling Modules

Function	C1000-V0-H	C1000-V1(V2)-HE	C1000-V1(V2)-C-0
Control Method	On/Off	On/Off	PID
Cooling Medium	Water ⁽¹⁾	Glycol/Water ⁽²⁾	Glycol/Water ⁽⁴⁾
Temperature Range	Ambient to +400° C	Ambient to +400° C	0° C to +400° C
Temperature Resolution	1.0° C ⁽³⁾	1.0° C ⁽³⁾	0.1° C ⁽³⁾

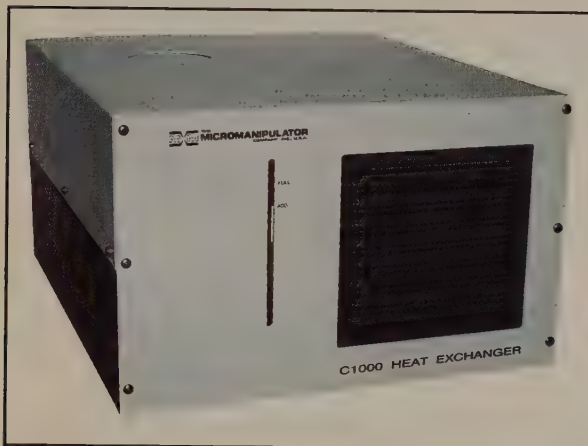
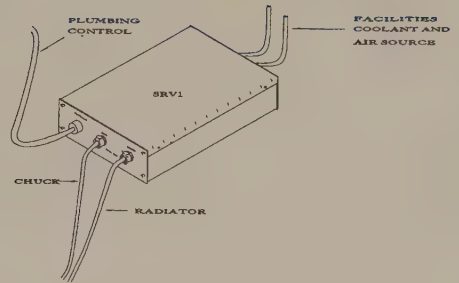
- Notes:
- (1) Source must be supplied by user (not self-contained).
 - (2) Self-contained heat exchanger has a 2.5 gallon reservoir.
 - (3) Temperature control above ambient performed by heat controller with 0.1° C resolution.
 - (4) Chiller has 2 liter reservoir.

H1000 System Cooling Options

C1000-V0-H

The C1000-V0-H cooling option is a economical way to quickly cool the thermal chuck using water supplied by the user. Cooling water is automatically purged after the cooling set point temperature is reached.

The Service Module (shown right) is designed to be located external to the electronic control equipment to eliminate the danger of fluid leaks causing equipment damage. For more information, see C1000-V0-H Cooling Option specification sheet A1011206.



C1000-V1(V2)-HE

The C1000-V1(V2)-HE is operationally equivalent to the C1000-V0-H cooling option. The heat exchanger (shown left) however, is fully self-contained and eliminates the need for the user to supply cold water and drain to cool the thermal chuck. The heat exchanger incorporates all functions of the Service Module and can be used as a direct replacement for the Service Module in upgrade applications. For more information, see C1000-V1(V2)-HE Cooling Option specification sheet A1011207.

C1000-V1(V2)-C-0

The zero degree cooling option provides chuck cooling capability down to zero degrees Celsius. The zero degree chiller (shown right) is used in conjunction with the Cooling Control Module and Service Module (shown above, right side) to control the thermal chuck temperature. The fluid from the chiller is used to cool the external cooling shield and thus also permits stable temperature control with the heat module at temperatures from near ambient to zero degrees Celsius. For more information, see C1000-V1(V2)-C-0 Cooling Option specification sheet A1011208.



HC1000 Temperature Control System

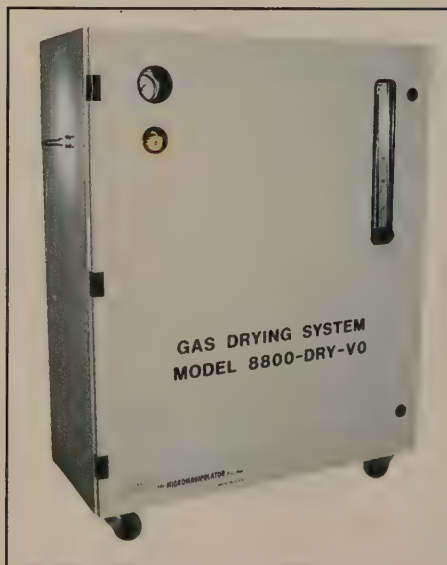
The HC1000 System (shown right) is an integrated temperature control product which has the capability of controlling the temperature of the thermal chuck through the range of -65°C to $+400^{\circ}\text{C}$. The HC1000 system incorporates the same heating technology that is used in H1000 System and is available both AC and DC configurations. A two-stage refrigeration system is used to provide a source of cooling fluid to control the thermal chuck temperature to -65°C . For more information, see HC1000 System specification sheet A1011209.

Control Method	PID
Cooling Media	Flourinert type fluid or Methanol for thermal chuck (1.32 gallons). Glycol/water mixture for cooling shield (2.5 gallons).
Temperature Range	-65°C to $+400^{\circ}\text{C}$
Temperature Resolution	0.1°C



Ultra Low Temperature System

Dryer System



Gas Drying System

Dryer System for 8800-TEMPSEAL and 8800-DRYSHIELD

- Dryer system for supplying clean, dry air to 8800-TEMPSEAL, 8800-DRYSHIELD or other closed systems.
- Compressed air input must be maintained from 80-100 PSIG at up to 15 SCFM.
- Regulated flow output adjustable from 1-14 SCFM.
- 0.3 micron particle filter at output to protect probe station and device under test (DUT).
- Filtering system traps liquids at air input.
- Output air dewpoint to -73°C at 100 PSIG input.

(Specifications subject to change without notice.)

The Micromanipulator Co., Inc.

Basics of Low Current Probing

Abstract

Useful as a primer for beginners and a refresher for those experienced in making low current measurements, this application note describes the fundamentals of making low current (femtoampere level) measurements using a probe station.

Proper set up, shielding and guarding considerations are discussed. Equipment needs to provide the correct probing environment are described. The application note discusses a series of problem areas typically encountered when doing low current probing and recommendations for solutions to these problems.

Introduction

The need to observe device behavior at femtoampere (fA) levels is being driven by the ongoing reduction in the geometric size of MOSFET devices to increase circuit density, facilitate higher speeds, and reduce power consumption. Decreasing the scale of the circuit can help provide the aforementioned improvements; however, tradeoffs in performance will also occur. For this reason, it is necessary to have the tools available to observe the new operating characteristics for comparison with the predicted values. The measurement of current values in the range of 1 to 100 fA is difficult because the quantity of current is so low that many interfering sources exist that are capable of generating this minuscule flow of electrons. To put this into perspective, consider this:

1 fA (1×10^{-15} ampere) is equal to a flow rate of 6,242 individual electrons per second compared to the 6.242×10^{18} electrons per second that defines an ampere. Be forewarned that care and deliberation will be required to setup a system capable of measuring currents down to these delicate levels.

Representative low current measurements

The grounding and shielding techniques needed for low current measurements will be defined for two typical probe contact configurations; *Surface to surface* and *Surface to substrate*. In the examples to follow, the surface to surface configuration will be represented by

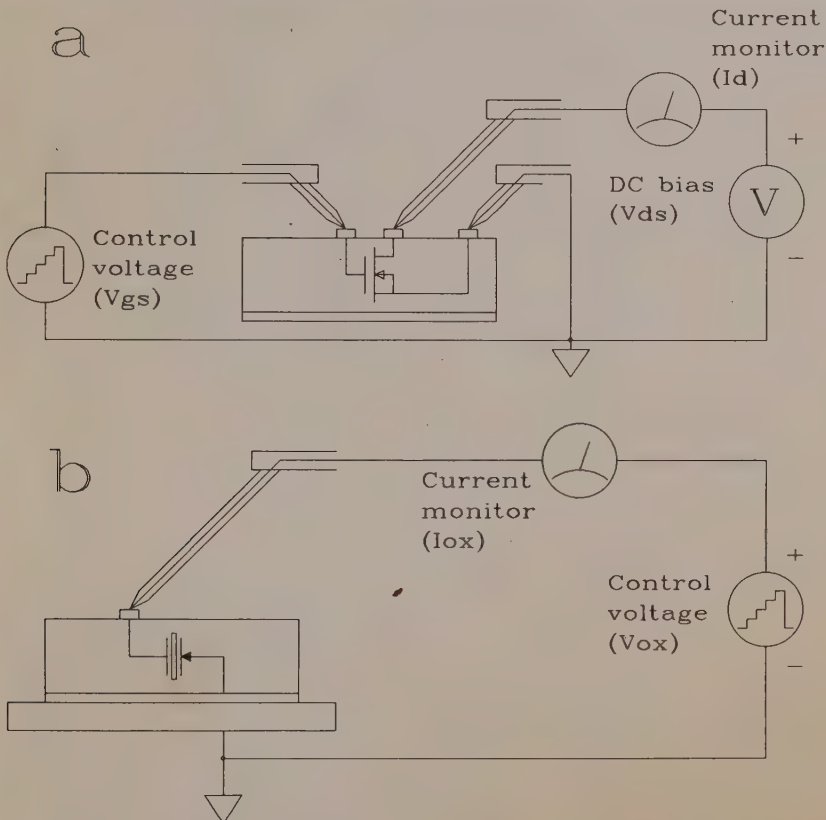


Figure one. Idealized representations of surface to surface and surface to substrate current measurements for (a): MOSFET subthreshold characterization. (b): Time Dependent Dielectric Leakage characterization. Grounding and shielding requirements and practical SMU connections.

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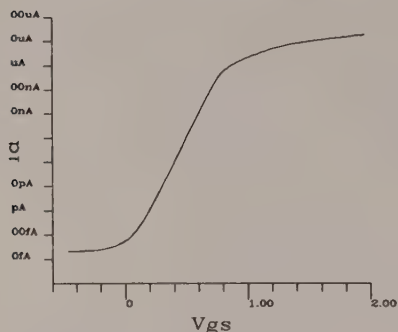


Figure two. A typical MOSFET subthreshold characterization curve. Made with a Micromanipulator Model 79 triaxial guarded probe on an un-guarded chuck.

MOSFET subthreshold measurements, and the surface to substrate measurements by time dependent dielectric leakage observations (TDDL). These configurations are shown in *figure one*. Subthreshold measurements permit the analysis of drain current behavior below the gate turn on voltage. This off state drain current is typically much less than 100 femtoamperes and will influence DRAM memory refresh requirements. A subthreshold curve is shown in *figure two*.

TDDL characterization identifies the behavior of gate oxide leakage under the influence of high electric field stress to thin insulating (e.g. oxide) layers. This behavior is of interest for the reliability of EPROM and flash memory devices because write/erase cycles will cause an increase in leakage current over time. This current will be in the femtoampere range and can influence component leakage and other aspects of device performance resulting in eventual circuit failure. A TDDL curve is shown in *figure three*.

Source Measure Units

Subthreshold and TDDL characteristics are graphically analyzed and both require a voltage for the stimulus or *source* which produces a current as the response or *measured* value. A *source measure unit* (SMU) is commonly used to facilitate this stimulus and response

function. A SMU is capable of being configured to:

- *Source current and measure voltage*
- *Source voltage and measure current*

SMUs have two features that facilitate measurement accuracy. When IR drops in the cabling between the SMU and the DUT are a concern, remote voltage sensing is available. If leakage paths and stray capacitive charging in the fixturing approach expected DUT current levels, a guard voltage output can be used to minimize the influence of these paths. *Figure four* shows the configurations that will be used in the examples to follow.

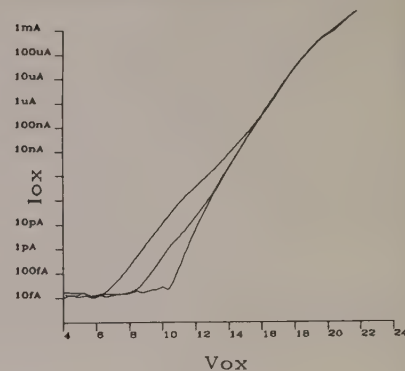


Figure three. A typical Time Dependent Dielectric Leakage curve family derived from circuit b in *figure one*.

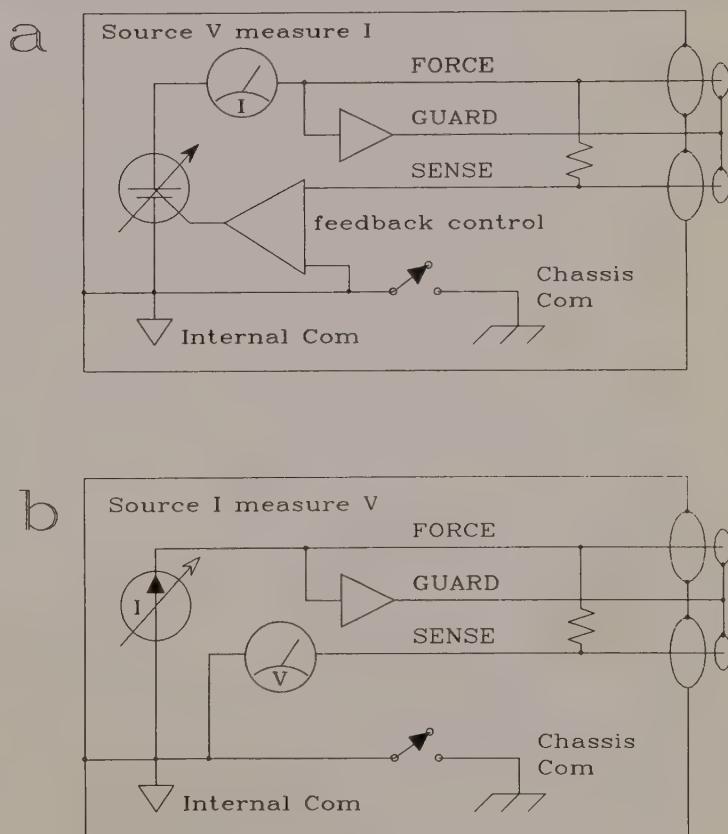


Figure four. The two generalized basic configurations for Source Measure Units. (a): Source V, measure I. (b): Source I, measure V.

Factors affecting the low level environment

A number of factors can adversely affect your low level measurements. The very brief descriptions that follow are provided to help you form an intuitive basis for identifying and minimizing either the *noise source* or the *noise coupling mechanism*. Use these descriptions to visualize the *relationships* between noise and signal and to alter your experimental measurement setup to better isolate the noise from the signal. For more detailed information on the mechanisms described, refer to the reference texts listed at the end of this paper.

Remember that the noise coupling mechanisms are best described as "virtual components" in that they will not be obvious or localized as would a lumped equivalent component.

Common impedances

A common impedance is an impedance or current path unintentionally shared by a source of noise and the receiving instrumentation. The noise source causes current to flow through the common impedance. If this common impedance is in parallel with the instrument's input, a noise voltage will be coupled into the measured signal with the relationship:

$$v_{noise} = i_{noise}(Z_{coupling})$$

If the instrument is measuring current, then the current flowing through the common impedance will algebraically sum with the signal current at the connecting node.

Prevention measure: Analyze the grounding scheme and verify it conforms to single point grounding practice. Confirm that current paths between different circuit functions are isolated. Inspect the physical test setup and eliminate all casual, unintended contact between ground conductors that reside in different electrical parts of the circuit.

Incidental mutual inductance

Transfer of a noise voltage can occur through mutually coupled inductances in the noise circuit and the signal circuit. This inductive coupling will have the relationship:

$$v_{noise} = M \frac{di_{noise}}{dt}$$

M is the mutual coupling between the noise circuit and signal circuit and will be influenced by proximity and shared length of noise and signal conductors.

v_{noise} is the noise voltage coupled into the signal circuit and is proportional to $\frac{di_{noise}}{dt}$ which is the time derivative of the noise current.

Prevention measure: Eliminate common runs of conductors and cables, especially conductors not a part of the test signal circuitry. Maintain wide conductor spacing where possible. Isolate circuits with magnetic shielding where practical.

Magnetically coupled noise

Typical noise sources that lend themselves to magnetic coupling are motors, transformers and facility wiring. The coupling mechanism can be expressed as:

$$v_{noise} = 2\pi fBA \cos\theta$$

f is the frequency of the noise signal, B is a measure of the noise magnetic field strength, A is the area of a closed loop in the signal circuit and θ (theta) is the angle of B to the plane of the loop area A .

Prevention measure: Remove unnecessary sources of electromagnetic energy in the area of the test circuit. Eliminate circuit loops. Magnetically shield wires or use twisted pairs.

Incidental capacitive coupling

A source of noise current can be coupled to the measurement circuit via stray capacitance according the relationship:

$$i_{noise} = C_{coupling} \frac{dv_{noise}}{dt}$$

$C_{coupling}$ is the stray capacitance between the noise source and the measurement circuit. This noise current will be proportional to the voltage rise and fall times of the adjacent noise signal and proportional to the amount of stray capacitance between noise conductor and signal conductor. Stray capacitance is inversely proportional to the distance between conductors. If the circuit of interest has a high impedance, it will see a noise voltage. If the impedance is low, a current will be developed.

Prevention measure: Add distance between unshielded noise sources and the test circuit. Separation of two wires by a distance greater than 40 diameters will provide good electrostatic isolation.

Ensure the test circuit conductors are shielded to redirect capacitively coupled current away from the test circuit to ground. Active guard shields will also provide good protection.

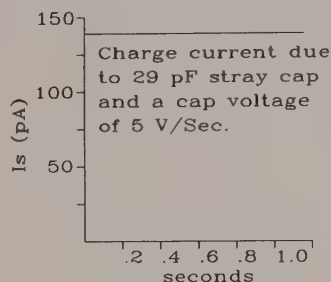
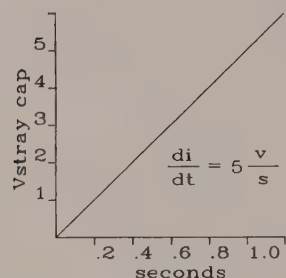
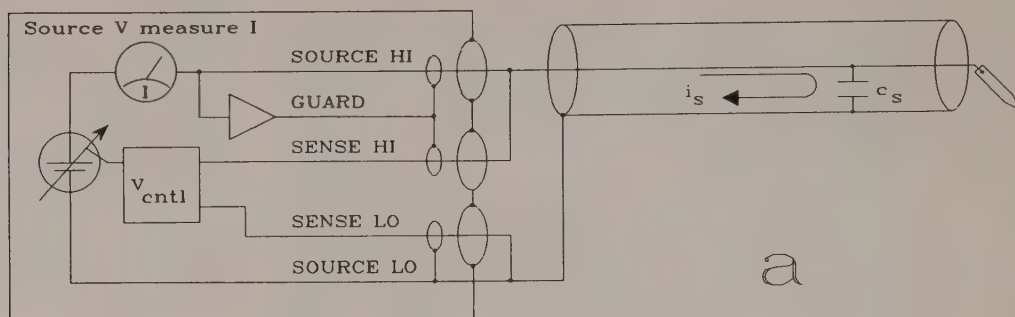
Charge transfer

If a charged body is brought in proximity to the test circuit, that charge will attract or repel charge in the test circuit and cause momentary electron flow. This will perturb femtoampere measurements. A human body is the typical charge vehicle.

Prevention measure: Limit activity in the area of the test setup during measurements. Provide broad electrostatic isolation by using a metallic light tight enclosure (LTE). Run interconnecting cables between the LTE and SMU behind the test bench away from traffic and AC power cords.

Stray capacitance charging

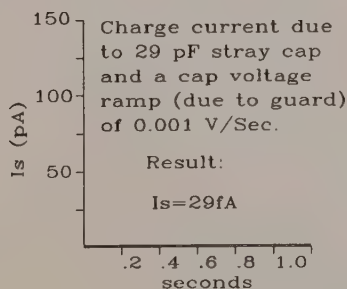
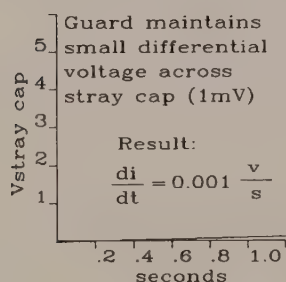
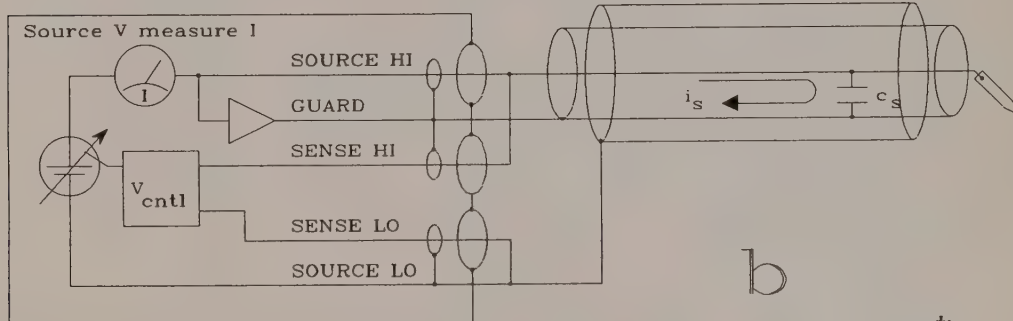
The voltage supplied by the SMU for subthreshold and TDDL measurements will typically be a stepped sweep of increasing voltage over time. Stray capacitance in the cables and shield surfaces between the SMU and DUT must be charged which will introduce an added current that will swamp the DUT current as shown in *figure five*. For low current measurements, this will be a major source of error.



$$i_s = C_{cable} \frac{dv}{dt}$$

$$i_s = 29 \times 10^{-12}(5)$$

$$i_s = 145 \text{ pA}$$



$$i_s = C_{cable} \frac{dv}{dt}$$

$$i_s = 29 \times 10^{-12}(0.001)$$

$$i_s = 29 \text{ fA}$$

Figure five. The settling time influence of cable (stray) capacitance. Proper connection of the guard from the SMU to the cable shield will significantly reduce or eliminate this source of error. The numerical example shows just how significant a reduction in charge current guarding can make. In this case, charge current is reduced by **three orders of magnitude** (a reduction of 5000 to 1)! Similar reduction of leakage current through insulation resistance can also be expected. Reduction of stray capacitance effects in the substrate circuitry is likewise attained by using a guarded (triaxial) chuck.

Prevention measure: Use an active guarded shield on all cables to keep the differential charging voltage to a very small level. Use probes or probe holders that have guard shielding as close as practical to the probe point. Evaluate the settling time requirement after guarding is in place, and be sure to program an adequate measure delay time into the SMU.

Light

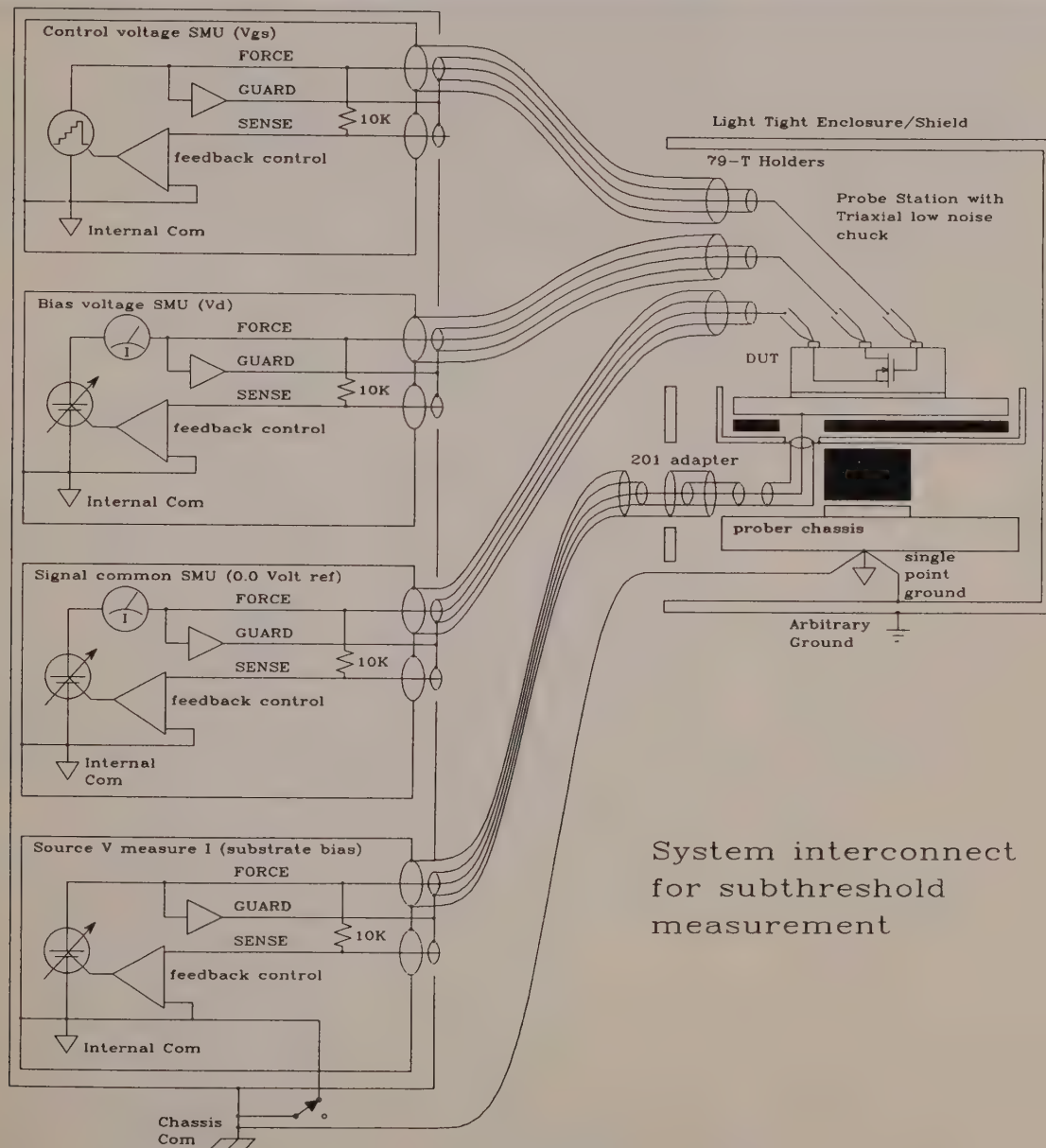
Semiconductor devices can be light sensitive. This is especially true for MOS-FET devices that rely on minority carriers for conduction. At femtoampere levels, the currents induced by exposure to light will obliterate many measurements.

Prevention measure: Use a light tight enclosure (LTE) to provide a dark envi-

ronment around the DUT. This serves to block all forms of electromagnetic radiation, not just the visible spectrum.

Intrinsic noise sources

At low femtoampere levels, most coaxial and triaxial cables will show current developed by triboelectric effects caused by flexing or vibration of the cable. Contacts between dissimilar metals as might be found in connectors, crimp joints or



System interconnect
for subthreshold
measurement

Figure six. Shielding, grounding and guarding scheme for low current surface to surface measurements with a parametric tester having an internal common reference.

solder joints will develop temperature sensitive Seebeck voltages (thermal noise). Moisture combined with chemical residue left over from an assembly process can produce an electrochemical voltage.

Prevention measure: Minimize triboelectric errors by allowing cables to relax after installation. Anchor cables to prevent motion. Prevent Seebeck effect and electrochemical voltages by making connections with similar metals, and keeping connectors clean and dry.

Leakage current

All insulation used in cabling, connectors and probes will permit a degree of leakage that can influence femtoampere measurements. Some of this leakage is inherent to the insulating material, and additional leakage may sometimes be contributed by contamination during assembly or handling.

Prevention measure: Use an active guarded shield on all cables to keep the differential voltage to a very small level.

Guidelines for successful low level measurements

Pay attention to the details

Because of the very small physical values being observed, many factors can interfere with the desired measurements. Thus it becomes important to review and practice the prevention measures given previously to eliminate problems before they occur.

Diagnose noise sources and minimize their effects

The biggest difficulty related to solving noise problems at femtoampere levels is that analog time domain measurement techniques are not readily available that will permit direct observation of the low level noise. When a noise waveshape can be seen in real time, its behavior can be compared to external events, and coupling mechanisms can be deduced and modified to reduce their influence. Since this luxury probably will not exist, the next best tool will be your

parametric tester configured to provide a sampled sweep of *current versus time with a constant source voltage*. When used this way, the filtering and averaging options should be set to minimum to improve its use as a noise diagnostic tool. By observing the sampled noise in this way, possible sources and coupling paths to noise can be identified and altered while observing the effects of the alteration.

System grounds, shields, and connections

The ideal grounding, shielding and connection scheme for surface to surface and surface to substrate current measurements are shown in *figures six and seven*.

Exploit filtering and averaging available in the instrument

Parametric measurements like sub-threshold and TDDL lend themselves to filtering and averaging. Use these features to obtain a clean, nominal representation of these DC characteristics.

Guarding and settling time

The use of a guarded signal path will be a key contributor to successful low current measurements. The driven guard output on a typical SMU will provide a buffered output voltage that follows the source output. Since the voltage difference between the signal path and guard shield will be nearly zero, the leakage current through the isolation will be maintained at very low levels. Charging delay (settling time) of the signal line will be substantially reduced for the same reason. Refer to *figure six and seven* for the recommended guard configuration. Compensate for the remaining settling time by adding the appropriate measurement delay to the SMU.

Cable Isolation and noise

Femtoampere current measurements will require very high resistive isolation and guarding between the signal path and all conductors at the reference potential. Specify cabling designed for low leakage such as cable insulated with virgin PTFE (Teflon) insulation. Most cabling will generate some degree of intrinsic noise especially when the cable is flexed

or vibrated, but most of this will subside after the motion stops. Cable designated as *low noise* is specifically manufactured to minimize triboelectric effects. When evaluating cables for leakage and intrinsic noise, allow the cable to relax into a limp position before making a leakage measurement. This requirement for a relaxed and motionless cable also applies when making real measurements. Note that the noise settling time could vary from seconds to tens of minutes depending on the cable type and characteristics.

Cleanliness

Avoid touching insulation between two conductors such as might be found around connectors, probes, shields, and guards. Oils or contamination on your fingers could cause an increase in leakage current.

Application of Micromanipulator products for low level measurements

Probing stations

The probing stations best suited for low current measurements are the 8060, the 8065 and the 8860 stations. The chassis is configured with a single point grounding scheme to minimize current generated by Seebeck voltages in the chassis. These stations also have the feature of providing isolated, independent electrical access to the chuck surface and chuck guard when used with the triaxial chuck (*see figure seven*).

Low noise enclosures

The 7000-LTE and 8800-LTE provide both a dark environment and electromagnetic shielding from external sources of noise. A key advantage to completely enclosing the probe station is that access to the wafer, probe and probe holder is convenient when compared to local, wafer only shielding.

The low noise chuck

The 8800-EVS-LN8 chuck is shown schematically in *figures six and seven*. This chuck will provide very high isolation to ground (with or without guarding), and is configured to permit the

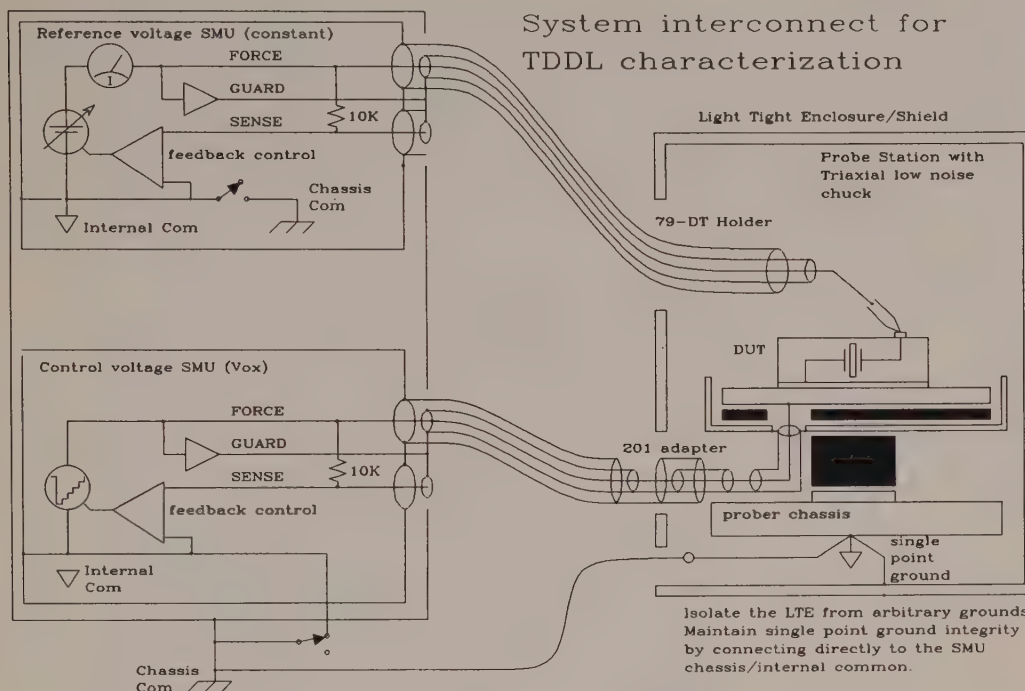


Figure seven. Shielding, grounding and guarding scheme for low current surface to substrate measurements.

application of a guard voltage to isolate the substrate circuitry from the effect of leakage and stray capacitance charging.

Probe holders with replaceable tips

Probes suitable for low current measurements are:

- 79-XXXX-T-02
- 79-XXXX-T-03

These probe holders have triaxial cabling which permits the use of the inner shield as a guard within close proximity to the replaceable probe tip.

For applications where currents at higher levels as well as low levels are of interest, a Kelvin type triaxial probe holder should be used to compensate for IR drop in the source voltage cable. The

part number for the Kelvin triaxial probe holders are:

- 79-XXXX-DT-02
- 79-XXXX-DT-03

Also suitable for low current probing (but with the caution on page 8) are the following:

- 79-XXXX-F-02
- 79-XXXX-F-03
- 79-XXXX-R-02
- 79-XXXX-R-03

These probe holders have coaxial cabling, and should be used with a Model 101 adapter (or equivalent). This adapter will route the inner shield from

triaxial cabling to the probe shield so that it will continue the guard down to the vicinity of the probe tip.

CAUTION: The guard voltage will be accessible at the BNC connector body. A potential shock hazard exists with the use of these probe holders especially if the guard voltage exceeds thirty volts. Isolate and insulate these connectors, and only handle the connector if the guard voltage is off.

44 series probes

All 44 series probes are coaxial. The particular advantage of this style of probe is an integral shield that extends to within 0.1 inches of the probe tip. Use this style of probe with 49-14 coaxial cables and a Model 101 adapter to extend

the guard shield to the probe shield. The following versions of 44 probes are appropriate for low current measurements:

- 44-XXXX-V-NA

CAUTION: The guard voltage will be accessible at the BNC connector body and at the exposed probe shield. A potential shock hazard exists with the use of these probe holders especially if the guard voltage exceeds thirty volts. Isolate and insulate these connectors, and only handle the connector or probe if the guard voltage is off.

Cables and adapters

Generic, triaxial cables intended for low noise applications are suitable for use in these low current applications. When adapters are required to connect BNC connectors to triaxial connectors, adapters that connect the triax inner shield to the BNC shield should be used. The adapters available from Micromanipulator are:

- *Model 101 triax male to BNC female adapter*
- *Model 201 triax female to BNC male adapter*

The 101 adapter is useful for connecting coaxial probes to triaxial cables. The 201 adapter will connect the triaxial chuck properly to triaxial cable through the chuck BNC connector.

Acknowledgments

Special thanks to the following people for sharing their knowledge, experience and time:

Lee Stauffer
Keithley Instruments, Inc.
Jim Forst
The Micromanipulator Co., Inc.
Dan Harrison
The Micromanipulator Co., Inc.

Summary

The need exists for low current measurements in the range of 100 to 1 fA due to the continuing trend toward decreasing geometric scale. Instruments are now available that can resolve down to 1 fA or below, and engineers involved in process and design are ready to make use of this technology. The factors that affect the low current environment are well known and can be modeled as "virtual components." These models will help the visualization of noise sources and noise coupling mechanisms when trying to deduce and eliminate error sources in the test system. Because noise at the femtoampere level is difficult or impossible to see in real time, the best measure against this source of error is prevention.

Further Reading

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IEEE Transactions on Instrumentation and Measurement, VOL. 38, NO. 6, December 1989: A Compact Self-Shielding Prober for Accurate Measurement of On-Wafer Electron Devices. Yamamoto.

Interfacing Micromanipulator Probe Stations to Your Measurement Equipment. Application Note, The Micromanipulator Co.

Application Note 238: Semiconductor Measurements with the HP4140B Picoammeter/DC Voltage Source. Hewlett-Packard Corp.

Application Note 315: Practical Applications of the HP 4145B Semiconductor Analyzer. Hewlett-Packard Corp.

Application Note 356: High Speed DC Characterization of Semiconductor Devices from Sub pA to 1A. Hewlett-Packard Corp.

Envisioning Your Test System? Watch for Error Sources. T. Mego, Keithley Instruments, Inc. R and D Magazine, September, 1992.

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Keithley 236/237 Source Measure Units Applications Overview. Keithley Instruments, Inc.

Keithley Application Note Series: Low Level measurements. Keithley Instruments, Inc.

Low Current / Low Noise Product Listing and Summary

Application Note

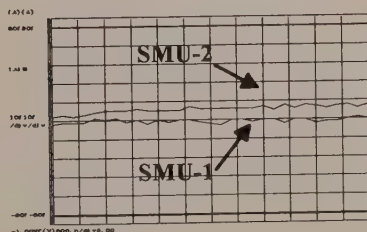
Abstract

Micromanipulator products that are available for low current / low noise probing are reviewed briefly and their key attributes are summarized.

The 8800 series of Micromanipulator probes has been designed to provide state-of-the-art probing systems for today's semiconductor devices. Key to the success of parametric testing with current devices is the ability to accomplish low current measurements. Several options are available for the 8800 (and other) series probes that enhance the system capability to accomplish these demanding measurements. The following key features and options are those directly affecting the success of low current measurements:

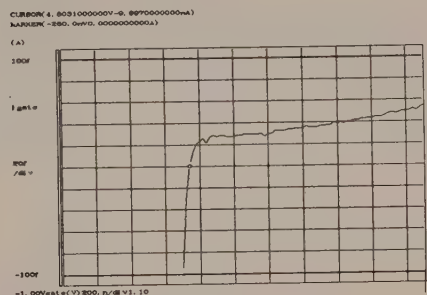
Results

Micromanipulator's products are designed to achieve results like the following;



Probe noise data showing triax probe (SMU-1) at less than 3 femtoamperes

*** HP 4156A GRAPH PLOT *** Apr 14 7:36:12 1995 PAGE 1
Igm (oxide leakage) test Gate sweep, T=26.7 C cooler



Diode sweep plotted at 20 fA per division

These results are achieved through the use of the following products and features:

1. Central Point Grounding

Ground loops in the probing station directly affect the electrical noise levels manifested. Current flowing through the ground loops may produce electrical noise sufficient to make it impossible to resolve the characteristics of the actual device measurement.

Micromanipulator's prober design has incorporated a special grounding technique. Ground straps connect all major chassis elements to one central grounding block inside the station. A connector on the side provides the user access to this ground point. The wafer surface of our standard vacuum chucks has better than 5×10^{-12} ohms electrical isolation from the chassis.



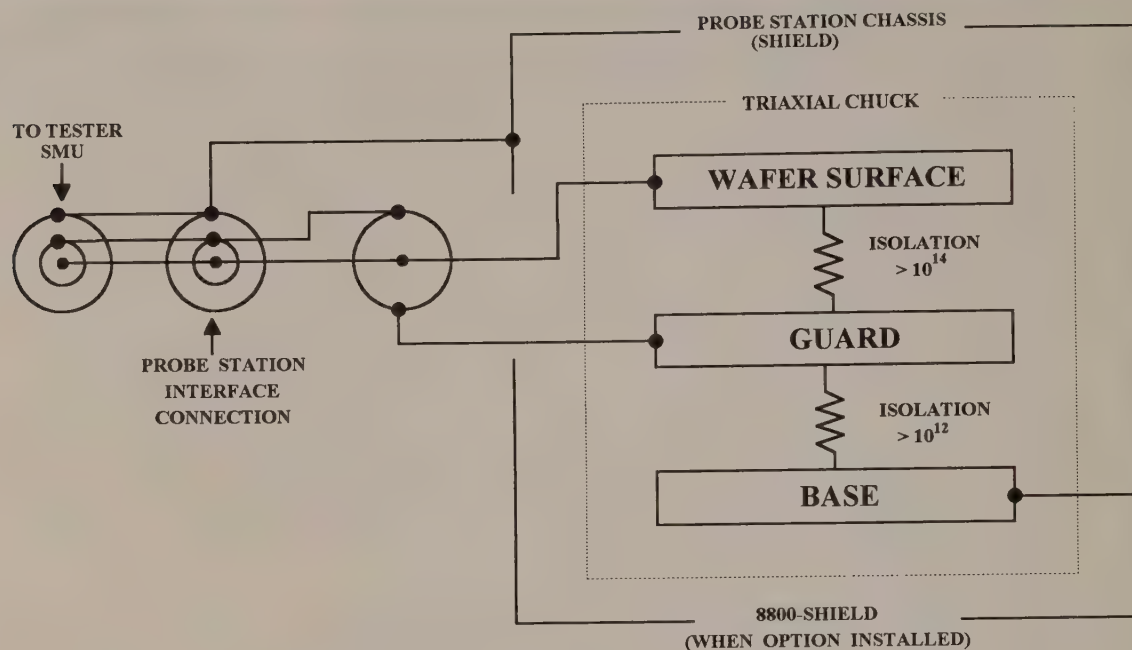
THE
MICROMANIPULATOR
COMPANY, INC.

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Carson City, NV 89706

tel: 702-882-2400
fax: 702-882-7694

E-Mail: sales@micromanipulator.com

2. Triaxial Wafer Chucks 8800-EVS-LN6 or 8800-EVS-LN8



**SCHEMATIC REPRESENTATION OF TRIAXIAL CHUCK
ON STANDARD 8800 SERIES PROBER**

A low noise chuck option is available for Micromanipulator probe stations (both 8800 and 6500 series). This unique design features:

- * Less than 20 femtoamp leakage.
- * Less than 30 second settling time.
- * Less than 5 femtofarad capacitance variation across chuck.

Note: Published performance specifications assume driven guard methodology.

Triaxial Chuck features:

- * 6" (150 mm) or 8" (200 mm) chuck diameter.
- * Non-Magnetic, Polished Annealed Stainless Steel Chuck Surface (No thermionic effects).
- * Triaxial (Signal, Forced Guard and Grounded Shield) construction.
- * Dual Triaxial (Kelvin) connectors available (optional) at the probe station interface.
- * High Isolation Component Materials and Mounting.

3. Dark, Shielded Enclosure (8800-SHIELD)

The 8800 series probes allow for the use of an integrated dark and/or electrically shielded enclosure which surrounds only the probe chuck and sample probing area.

These options, which are variations of the 8800 series TEMPSEAL™ low-temperature, dry probing environment enclosure (see 8800 TEMPSEAL™ Application Note), provide for probing in a dark environment or in an electrically shielded environment (or both) without the need for a large enclosure which surrounds the probe station.

Note: This configuration does require increased setup time.

The 8800-Shield option provides the following benefits:

- ♦ Large probe enclosure is not required.
- ♦ Improved EMI shielding as shielded environment is close to the DUT and may be part of the circuit electrical shield.
- ♦ Shielding from Electrostatic effects since ES currents are generated outside of the localized environment.
- ♦ Dark probing with easy access to manipulators, probes and microscope.

4. Probe Holders

Micromanipulator features probe holders designed to insure the signal integrity of the most demanding probing application. These complete the probing environment required to achieve clean results in low current, low noise situations. Custom and special probes are always available, however our wide range of standard probe holder offerings include:

Model 44:

Integral (fixed) single tip, low capacitance coaxial probes (SMA, UMC, other connectors available). Model 44 probes are available with shield grounding tips as well as integrated series or shunt resistors.

Model 44-D:

Integral (fixed) Dual tip (Kelvin), low capacitance coaxial probes (SMA, UMC, other connectors available).

Model 79:

Shielded (BNC, coaxial), disposable tip probe holders.

Model 79-D:

Disposable tip probe holders with dual (Kelvin) connections (BNC, coaxial) to tip.

Model 79-T:

Triaxial disposable tip probe holders (with low triboelectric effect cabling).

Model 79-TD:

Triaxial disposable tip probe holders (with low triboelectric effect cabling) with Kelvin connection (dual cables single tip).

5. Low Noise Drive Motors, and Driver Noise Filters (standard)

The Micromanipulator 6640 and 8800 series probe stations which feature motorized or programmable drives (for stage or microscope) incorporate a motor driver design and configuration which features the following:

- * Remote location from the probe station proper.
- * High performance, Low noise, drive signal filters at the driver output.

These features, coupled with a fiber optic microscope light source, provide the lowest noise probing environment available, and allow low femtoamp level measurements to be made with the Model 8860 programmable probe station WITH ALL PROGRAMMABLE COMPONENTS (microscope and stage) ACTIVE.

Measurement Data

Figures 1-4 are data from an HP-4156 Parametric Tester. Data is "noise" at the probe tip suspended 0.005" above the wafer surface over the grounded chuck of a semi-automatic 8860 probe station with programmable stage, manipulator and microscope. All motors energized (holding position). Microscope light is off. SMU-1 is 79-8000-T-03 Triaxial probe, SMU-2 is 44-8000-V-NA Coaxial probe. All data is at room ambient temperature.

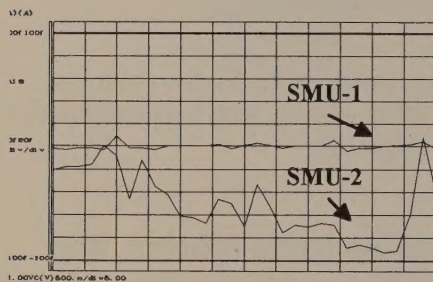


Fig. 1 Plot IRPS4506 Base condition, no shield

Note: High degree of noise especially on coaxial probe.

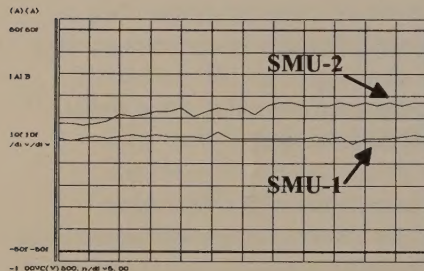


Fig. 2 Plot IRPS4508 closed LTE as shield

Note: Scale change and noise reduction to less than 3 femtoamperes on triaxial probe (SMU-1).

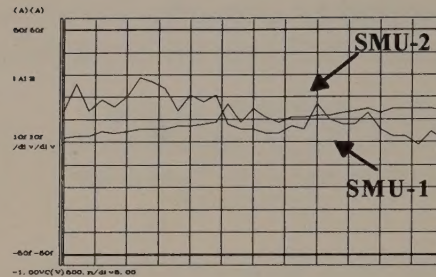


Fig. 3 Plot IRPS4504 8800-SHIELD, ONLY
Maximum noise on Triaxial probe (SMU-1) is 15 femtoamperes.

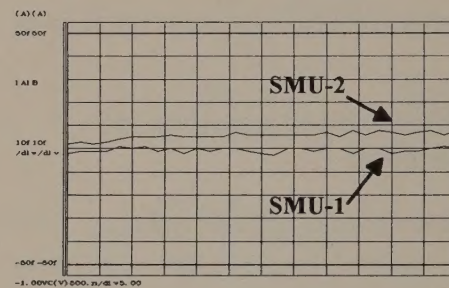


Fig. 4 Plot IRPS4505 LTE
with 8800-SHIELD COVER

Note: Triaxial probe is less than 3 fA, and coaxial probe (SMU-2) is less than 8 fA.

*For information on any of the above,
the latest in state-of-the-art
probing equipment and accessories,
or for assistance in your unique or difficult
probing application, contact your local
Micromanipulator representative or
the factory at*

Phone: (702) 882-2400

or (800) 654-5659 in the USA,

Fax: (702) 882-7694

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